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AN
AIR QUALITY STUDY
IN THE
DEER LODGE VALLEY
1971 - 1973

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Report Prepared By
James W. Gelhaus
June, 1974

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ACKNOWLEDGEMENTS

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1. INTRODUCTION

This report consists of an ongoing study of the quality of the ambient air in the Deer Lodge Valley of Montana. The data presented here was collected during the period January 1, 1971 though December 31, 1973 (except where noted).

Air Quality parameters included are particulates, sulfur dioxide, sulfation rates, and fluoridation. In addition, data are presented on the climatology and topography of the Deer Lodge Valley and emission sources of the valley. Also presented are collection and analysis procedures, diffusion modeling results for several sources in the valley, and particulate studies in the Butte area.

The appendices contain definitions of some commonly used terms; a list of sampling sites used during the period; and Montana and Federal air quality standards as a point of reference for the reader.

1.1 Population Centers

There are three major population centers in the Deer Lodge Valley. Butte, the largest, rests on the upper end of the valley and the west side of the Continental Divide. Anaconda, the next largest, sets in the mouth of a tributary valley on the east side of the Flint Creek Range twenty miles west of Butte. Deer Lodge is centered in the northern third of the Deer Lodge Valley. Deer Lodge is about twenty miles NNE of Anaconda and twenty-five miles NNW of Butte.

Several smaller population clusters in the valley exist and statistical information related to their population is noted in Table 1.1.

Table 1.1

City	1960 Population	1970 Population	Birth Rate (per 1000 Population)	Death Rate (per 1000 Population)
Butte	27,877	23,368	17.9	13.2
Anaconda	12,054	9,771	16.1	10.6
Deer Lodge	4,681	4,306	14.0	8.9
Warm Springs	500	500	--	--
Rocker-Ramsay	1,101	980	--	--
Garrison	200	150	--	--
State Average	--	--	18.2	9.5

1.2 Topography Summary

The Deer Lodge Valley is a "L" shaped depression consisting of the Silver Bow Creek Valley, Deer Lodge River Valley and the Upper Clark Fork River Valley. The Deer Lodge Valley is bounded on the south and east by the Continental Divide with mountain peaks exceeding 8000 feet. The Garnet Range with peaks near 7500 feet borders at the north end of the valley. Adjacent to the west side of the valley rests the towering Flint Creek Range with peaks exceeding 9000 feet.

The Deer Lodge Valley extends approximately sixty miles in length on a north-south orientation with an average width of near 12 miles. This intermountain valley which drains to the north through the Upper Clark Fork exhibits nearly 1000 feet of relief over sixty miles with river elevation on the north near 4200 feet.

Figure 1.1 shows the population centers of the valley and the relative position of the various mountain ranges with respect to the Deer Lodge Valley.

1.3 Climatological Summary

Near and within the Deer Lodge Valley were five National Weather Service (NWS) climatological stations. In addition to these climatological stations, the Montana Air Quality Bureau (AQB) maintained special wind monitoring sites during the past years. The location of the NWS climatological stations and the AQB wind monitoring sites are noted in Figure 1.2. The AQB wind monitoirng sites were operated in supplementary association with the sulfur dioxide continuous analyzers. Consequently, wind instruments were repositioned with transfer of the analyzers.

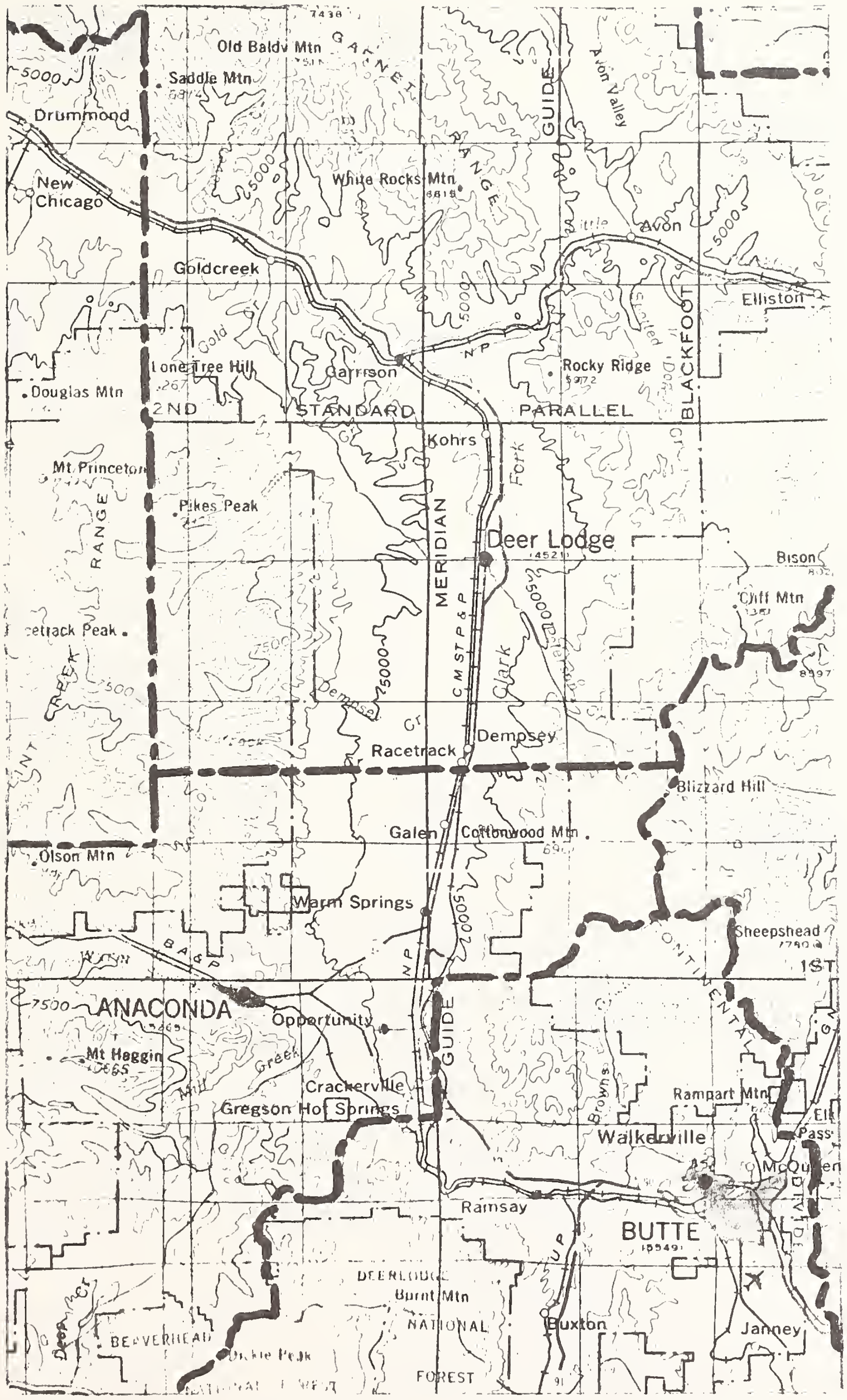
At least one and sometimes two wind monitors were located in Butte, Deer Lodge and Anaconda simultaneously. Wind roses for each of the sites are given in Figures 1.3 - 1.6. The duration of operation is also noted on the figures for each respective sites. Also wind roses from data supplied by the Anaconda Company for their two wind stations are given in Figures 1.7 and 1.8. Wind blows toward the center of the wind roses. Wind speed and direction are directly involved in the transport of air contaminants from point and multiple sources to the various receptors. During transport, dispersion and diffusion of contaminants occur in proportion to the amount of atmospheric turbulence.

Average temperatures, relative humidities and precipitation amounts are noted in Table 1.2 for the NWS climatological stations in the Deer Lodge Valley area for the period under concern. Normal temperatures and precipitation amounts are given in Table 1.3 for the same NWS stations (1).

With cold air drainage into the intermountain valley from the surrounding alpine terrain, inversions are likely. Winter inversion data from Missoula, Helena and Bozeman for October 1971 - June 1972 support this assumption. (See Figure 1.9). The valleys surrounding these three cities are similar to the Deer Lodge Valley in topographic settings. The likelihood of inversions in the Deer Lodge Valley may be even greater than that for Missoula, Helena and Bozeman because of the increased confinement provided by the surrounding mountains. Atmospheric stability is discussed further in Section 7.1.

Figure 1.1

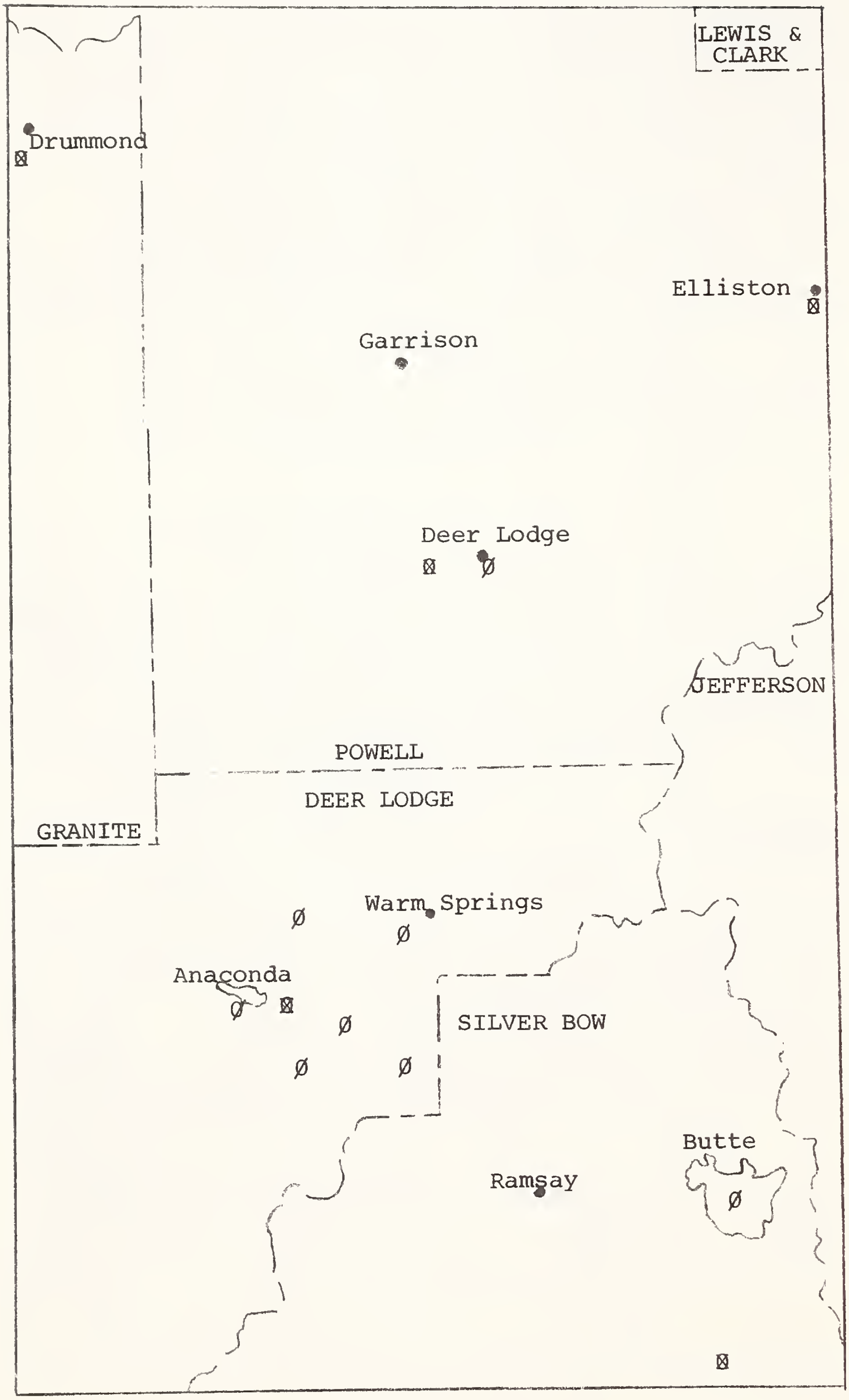
DEER LODGE VALLEY STUDY AREA



Scale 1" = 8 miles

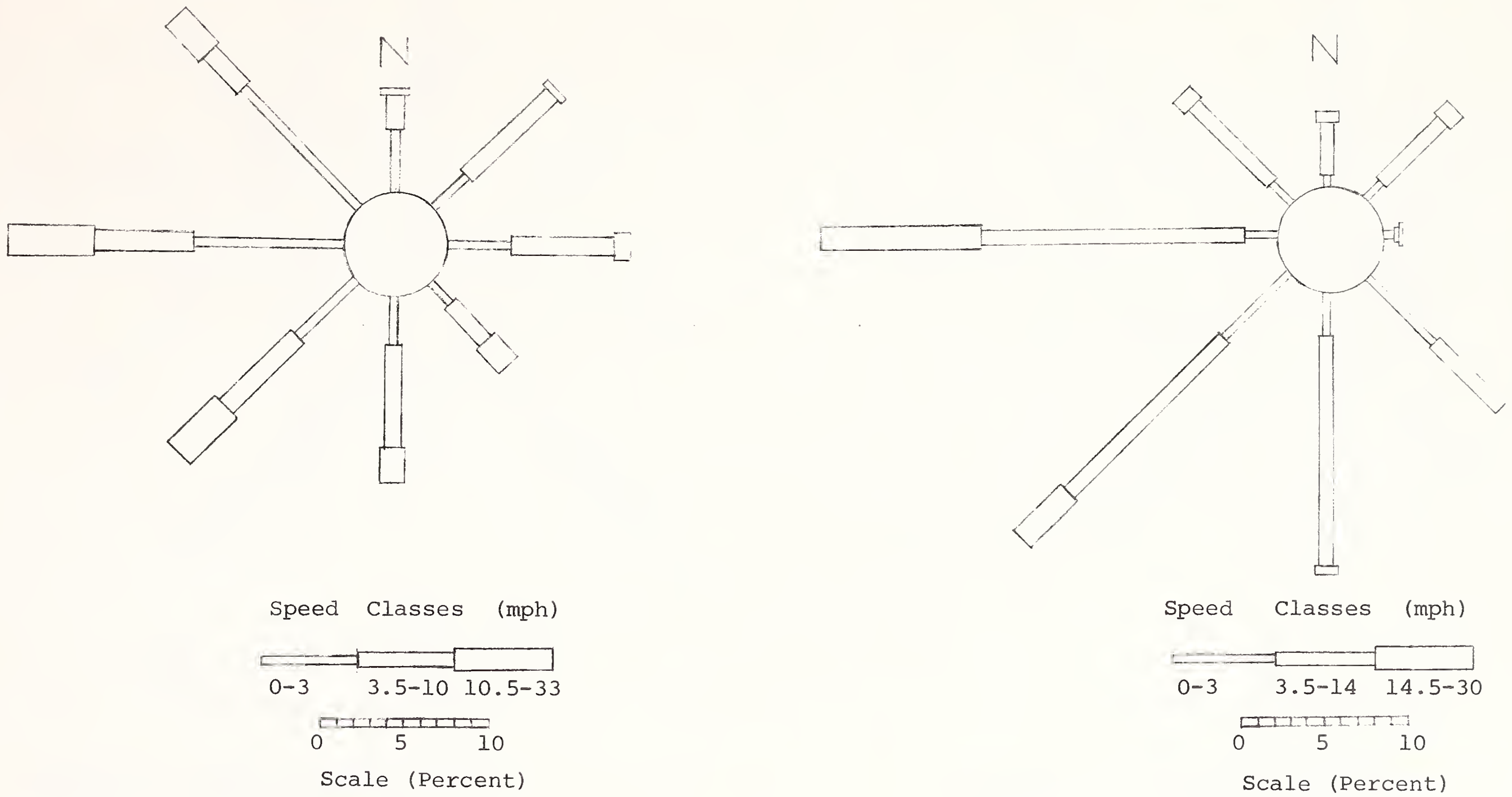
Figure 1.2

DEER LODGE VALLEY WIND
AND CLIMATOLOGICAL STATIONS



Scale 1" = 8 miles

KEY:
Ø AQB Wind Station
☒ NWS Climatolotical Station



Source: Montana Department of Health and Environmental Sciences (Air Quality Bureau)

Period: December 71 through January 73

Location: Deer Lodge County (Poor Farm)

Source: Montana Department of Health and Environmental Sciences (Air Quality Bureau

Period: October 71 through December 71

Location: Deer Lodge County (Baileys)

Figure 1.3

Source: Montana Department of Health & Environmental Sciences (Air Quality Bureau)

Period: August 71 through May 72

Location: Deer Lodge (Courthouse)

Source: Montana Department of Health & Environmental Sciences (Air Quality Bureau)

Period: September 71 through March 72

Location: Butte (Fire Station)

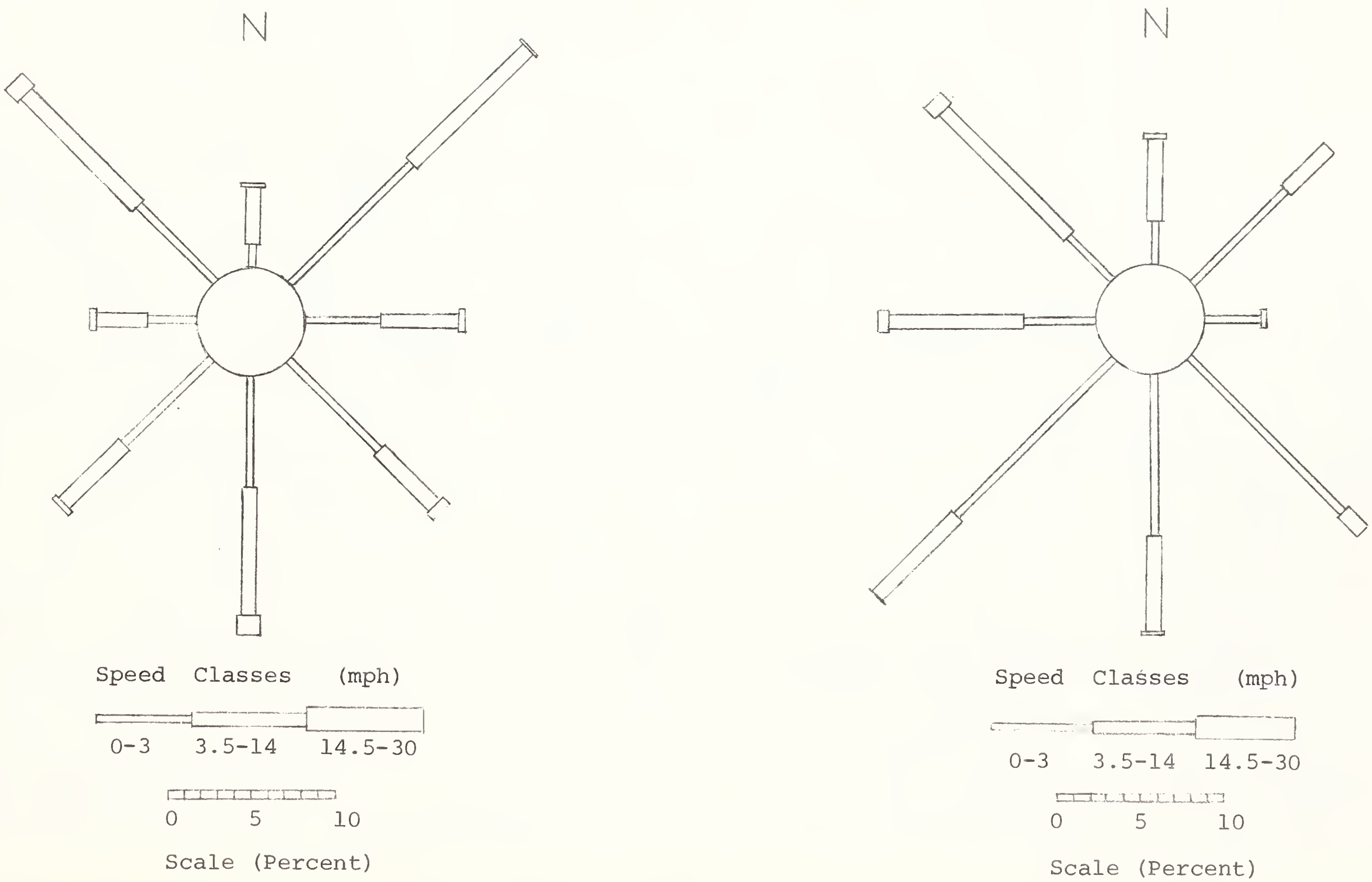


Figure 1.4

Source: Montana Department of Health & Environmental Sciences (Air Quality Bureau)

Period: June 72 through November 72

Location: Deer Lodge County (Opportunity Main Street)

Source: Montana Department of Health & Environment Sciences (Air Quality Bureau)

Period: December 72 through May 73

Location: Deer Lodge County (Kucera Residence)

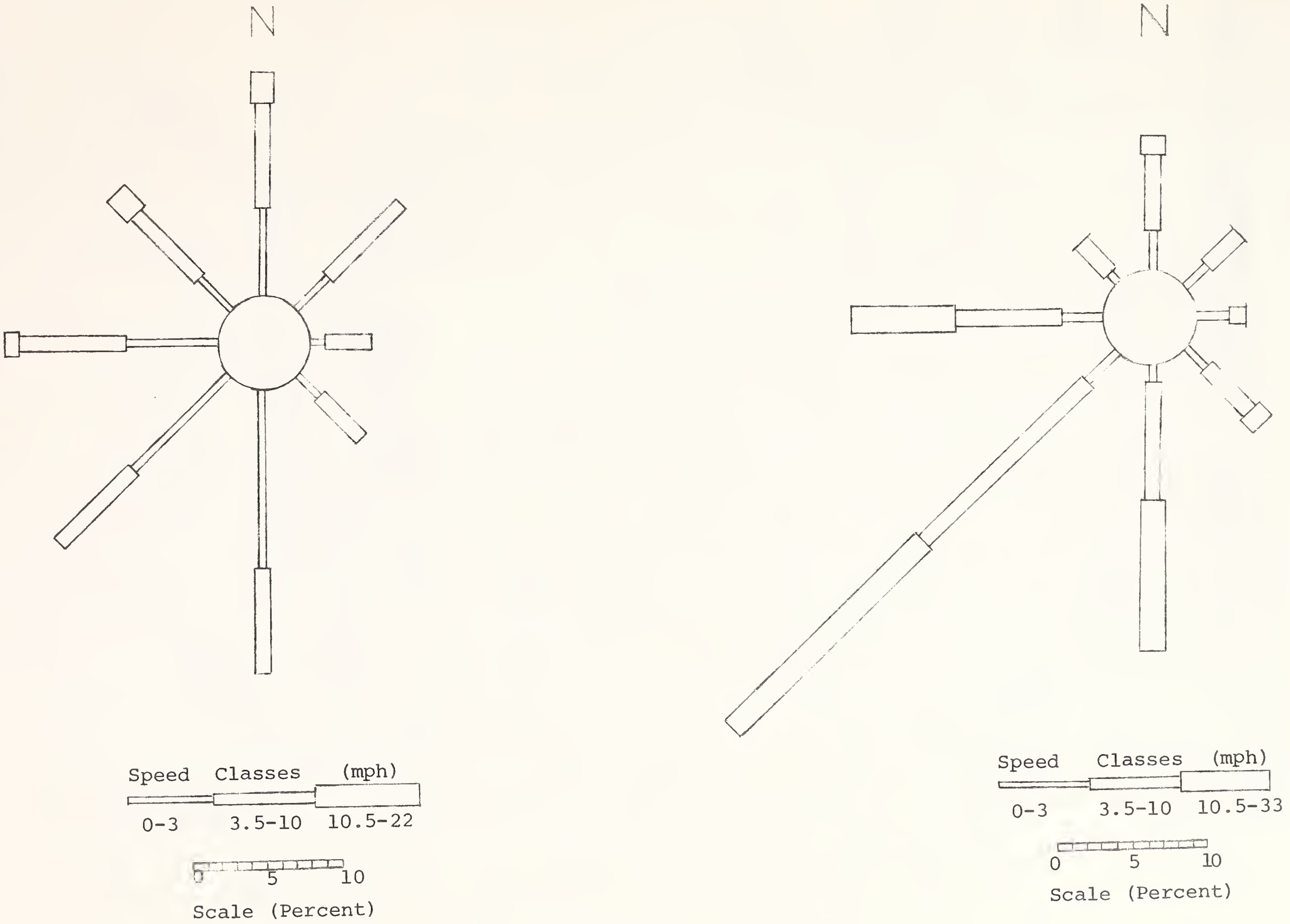
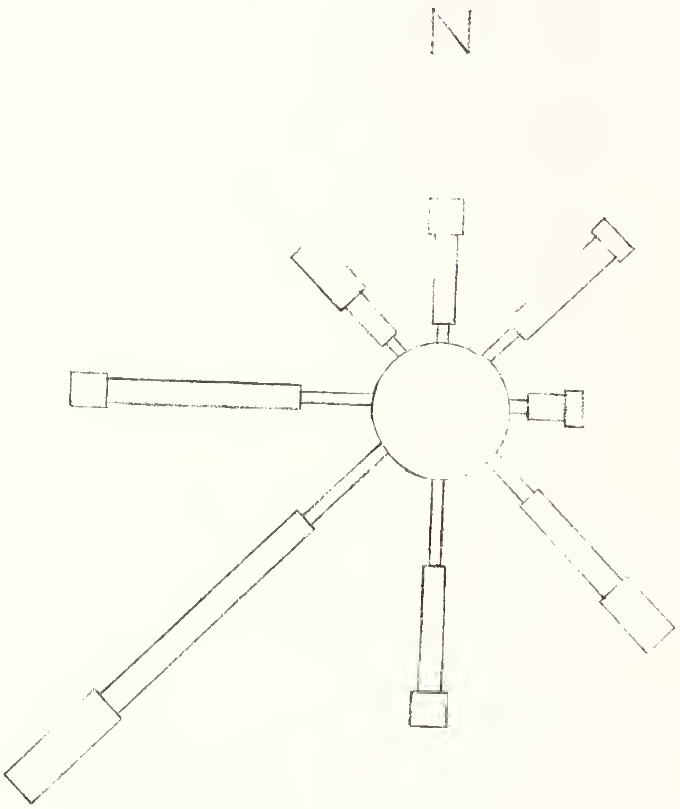


Figure 1.5

Source: Montana Department of Health and Environmental Sciences
(Air Quality Bureau)

Period: February, 1973 through August, 1973

Location: Deer Lodge County (Antelope Creek)



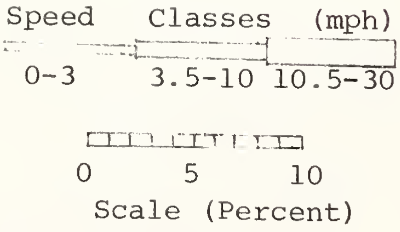


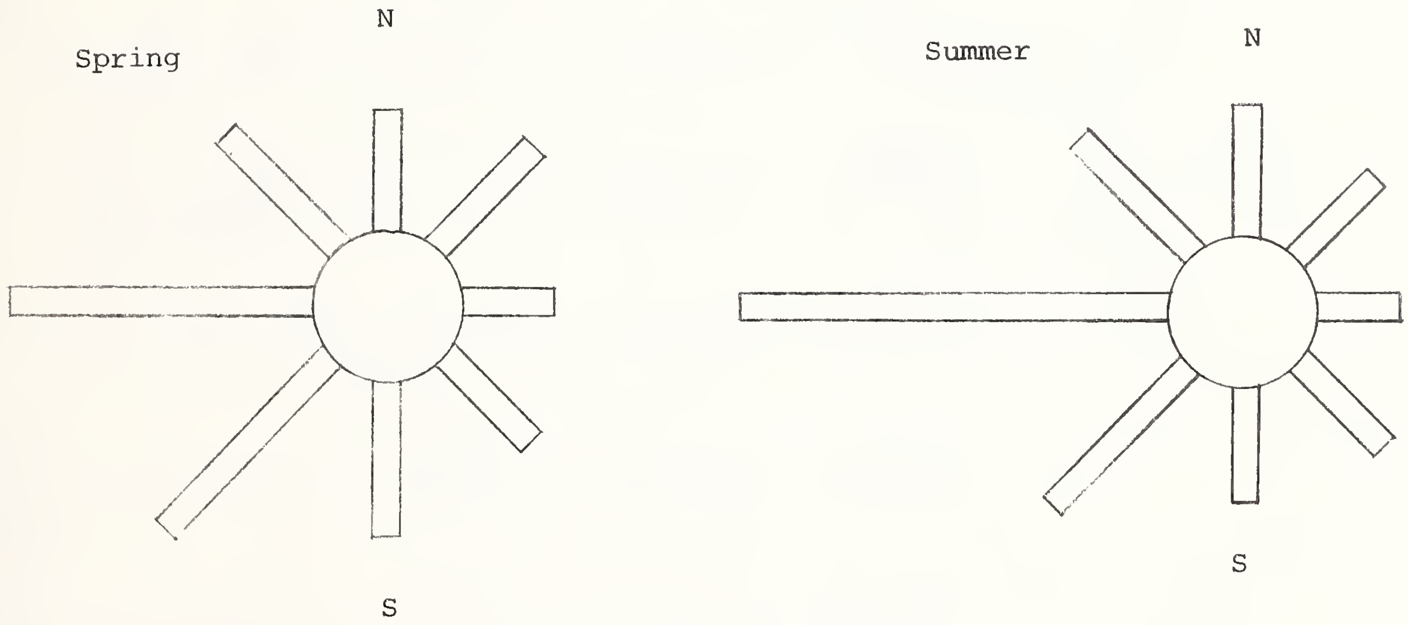
Figure 1.6

Figure 1.7

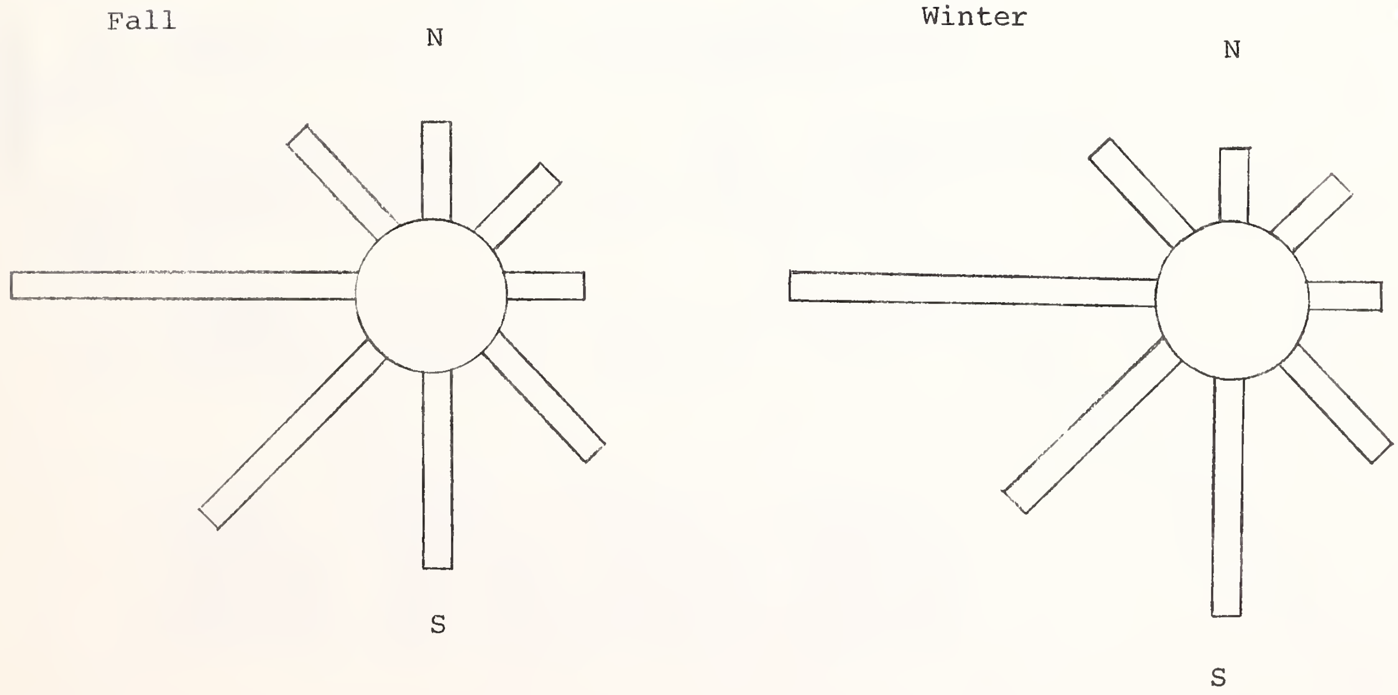
Seasonal Wind Roses (Direction Only) from Anaconda Company's Flat Station

Period: 1965 and 1967

Location: 4000 feet WNW of main plant complex in the vicinity of the railroad switch yard.


Spring

Summer


Fall

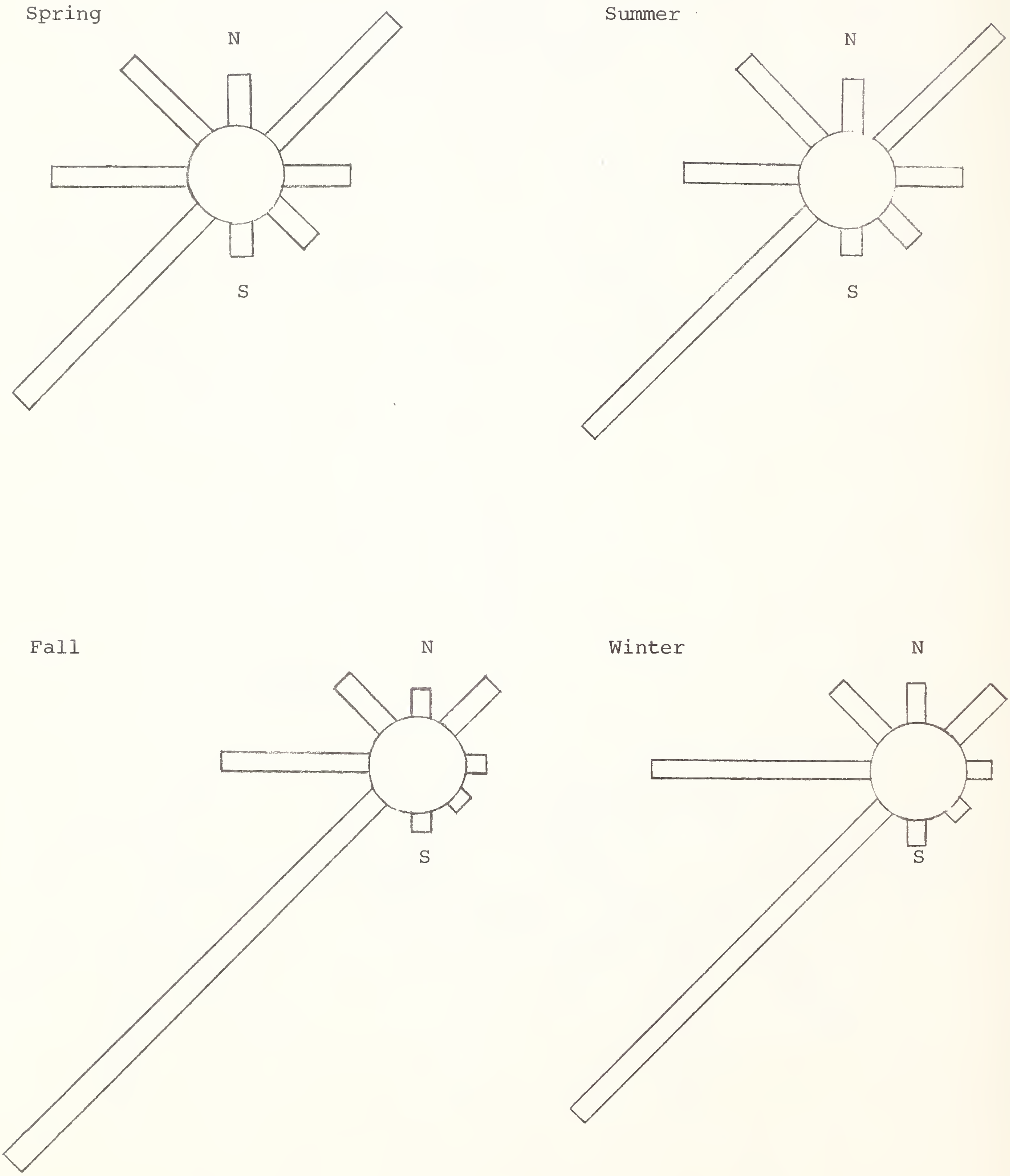
Winter

Figure 1.8

Seasonal Wind Roses (Direction Only) from Anaconda Company's Hill Station

Period: Seven Years

Location: 6000 feet N of main stack



Spring

Summer

Fall

Winter

TABLE 1.2
JANUARY 1, 1971 THROUGH DECEMBER 31, 1971

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Maximum Temperature (^{O}F)	Deer Lodge	34.2	37.9	41.4	53.3	65.5	69.8	81.3	88.1	65.3	54.7	42.8	29.5
	Drummond	34.5	40.4	44.9	58.4	68.0	72.6	84.2	90.1	67.7	56.7	43.1	28.2
	Anaconda	32.0	32.9	36.5	47.3	59.6	65.9	76.5	84.0	59.2	50.1	40.2	28.3
	Elliston	31.7	35.4	38.1	52.2	62.9	68.8	80.5	86.9	63.6	53.5	40.3	28.0
	Butte	32.5	36.1	37.9	49.3	60.9	73.4	79.6	86.7	61.2	49.7	39.8	26.9
Average Minimum Temperature (^{O}F)	Deer Lodge	15.0	18.0	18.4	26.3	34.1	39.4	41.7	46.0	32.8	25.6	20.4	7.1
	Drummond	16.7	19.7	21.9	26.8	35.7	40.5	40.9	43.4	31.8	26.2	22.6	7.8
	Anaconda	17.8	19.4	19.3	28.7	39.3	44.0	51.4	56.4	38.7	31.5	23.9	13.4
	Elliston	12.1	16.8	16.3	25.5	32.6	37.0	41.7	46.5	32.0	25.7	20.5	6.9
	Butte	13.8	18.0	15.2	26.4	35.4	43.6	44.9	47.0	32.7	24.8	18.2	3.1
Average Temperature (^{O}F)	Deer Lodge	24.6	28.0	29.9	39.8	49.8	54.6	61.5	67.1	49.1	40.2	31.6	18.3
	Drummond	25.6	30.1	33.4	42.6	51.9	56.6	62.6	66.8	49.8	41.5	32.9	18.0
	Anaconda	24.9	26.2	27.9	38.0	49.5	55.0	64.0	70.2	49.0	40.8	32.1	20.9
	Elliston	21.9	26.1	27.2	38.9	47.8	52.9	61.1	66.7	47.8	39.6	30.4	17.5
	Butte	23.2	27.1	26.6	37.9	48.2	58.5	62.3	66.9	47.0	37.3	29.0	15.0
Total Precipitation (Inches of Water)	Deer Lodge	.68	.39	.29	.84	1.15	.71	.23	1.22	1.04	.24	.57	.59
	Drummond	1.12	.98	.53	1.04	2.92	1.16	.19	1.46	.87	.35	.60	1.06
	Anaconda	.41	.40	.30	.81	1.32	1.52	.43	.81	1.05	.51	.40	.77
	Elliston	1.44	.59	.56	1.35	2.26	1.03	.53	.86	.86	.43	.39	.92
	Butte	.71	.29	.29	1.01	1.64	1.83	.20	1.11	.92	.52	.46	.72

TABLE 1.2(Continued)
JANUARY 1, 1972 THROUGH DECEMBER 31, 1972

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Maximum Temperature (°F)	Deer Lodge	28.2	37.6	49.6	53.9	62.1	75.8	78.6	82.5	68.0	56.2	41.2	26.0
	Drummond	29.0	36.4	50.7	55.6	66.5	77.5	80.3	84.7	68.3	57.2	43.2	25.7
	Anaconda	27.4	34.8	45.1	47.2	58.5	69.6	72.4	77.5	60.4	50.4	38.9	24.4
	Elliston	27.5	36.3	46.3	49.8	60.9	73.1	74.8	80.8	65.0	55.0	40.8	23.5
	Butte	26.3	34.2	47.3	49.3	61.3	72.3	75.9	80.0	63.9	53.2	39.1	21.3
Average Minimum Temperature (°F)	Deer Lodge	8.0	15.6	25.3	24.2	32.8	41.2	43.3	45.3	32.6	25.4	17.5	4.8
	Drummond	10.3	15.9	26.7	26.1	35.1	43.9	44.6	45.5	33.7	27.3	18.6	6.2
	Anaconda	12.1	20.4	26.6	25.8	38.3	45.8	48.8	52.0	39.1	30.9	22.9	9.9
	Elliston	6.8	13.6	24.2	24.1	33.3	40.6	42.0	42.5	31.7	23.0	17.1	3.6
	Butte	7.3	11.3	25.1	25.1	34.3	43.6	44.9	46.8	34.6	25.4	16.3	1.9
Average Temperature (°F)	Deer Lodge	18.1	26.6	37.5	39.1	47.5	58.5	61.0	63.9	50.3	40.8	29.4	15.4
	Drummond	19.7	26.2	38.7	40.9	50.8	60.7	62.5	65.1	51.0	42.3	30.9	16.0
	Anaconda	19.8	27.6	35.9	36.5	48.4	57.7	60.6	64.8	49.8	40.7	30.9	17.2
	Elliston	17.2	25.0	35.3	37.0	47.1	56.9	58.4	61.7	48.4	39.0	29.0	13.6
	Butte	16.8	22.8	36.2	37.2	47.8	58.0	60.4	63.4	49.2	39.3	27.7	11.6
Total Precipitation (Inches of Water)	Deer Lodge	.56	.50	.48	.35	1.41	1.05	.47	1.36	.81	.32	.32	.55
	Drummond	1.90	.87	1.26	1.15	1.59	1.16	.91	1.16	1.24	.95	.31	1.40
	Anaconda	1.98	1.12	.43	.42	1.50	1.00	1.38	1.05	.61	.42	.17	.97
	Elliston	1.45	1.41	1.24	.74	.75	1.08	.75	1.21	.82	.48	.25	.73
	Butte	1.10	.26	1.39	.36	.64	1.23	.78	1.24	.42	.26	.17	.51

TABLE 1.2 (Continued)
JANUARY 1, 1973 THROUGH DECEMBER 31, 1973

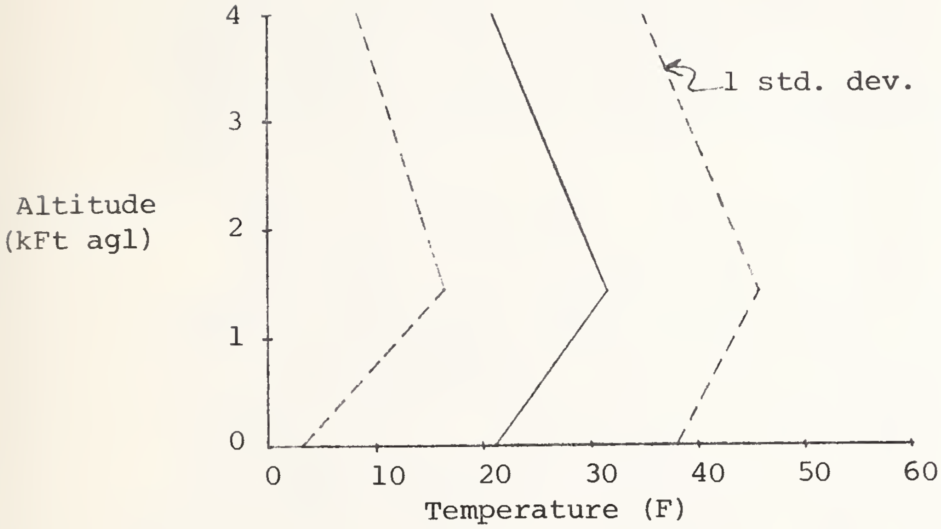
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Maximum Temperature (°F)	Deer Lodge	30.5	38.0	45.5	51.1	65.3	72.6	84.1	82.5	66.7	58.6	37.7	37.3
	Drummond	29.9	39.3	50.2	54.6	69.2	74.5	87.0	84.8	70.3	58.9	36.4	34.7
	Anaconda	28.4	36.2	39.7	45.9	62.4	67.9	80.2	78.0	62.1	52.9	35.1	34.6
	Elliston	27.4	36.1	42.3	47.6	64.8	71.5	83.4	81.0	65.6	55.6	36.5	35.6
	Butte	25.8	31.3	40.1	46.4	63.5	69.7	82.1	80.3	65.0	55.6	36.0	34.0
Average Minimum Temperature (°F)	Deer Lodge	8.1	10.6	22.3	24.8	32.2	41.4	43.3	44.5	36.4	29.1	21.3	19.0
	Drummond	8.2	11.9	24.1	26.3	32.6	43.6	43.5	44.0	37.2	58.9	20.2	21.9
	Anaconda	13.2	16.6	23.2	27.3	37.9	45.6	52.8	51.4	40.8	52.9	22.0	22.0
	Elliston	6.5	7.1	18.8	23.2	30.9	40.0	42.4	42.5	34.4	55.6	17.3	16.4
	Butte	1.8	-.9	18.5	24.6	32.3	42.0	46.0	45.3	35.8	55.6	18.6	14.0
Average Temperature (°F)	Deer Lodge	19.3	24.3	33.9	38.0	48.8	57.0	63.7	63.5	51.6	43.9	29.5	28.2
	Drummond	19.1	25.6	37.2	40.5	50.9	59.1	65.3	64.4	53.8	44.9	28.3	28.3
	Anaconda	20.8	26.4	31.5	36.6	50.2	56.8	66.5	64.7	51.5	43.5	28.6	28.3
	Elliston	17.0	21.6	30.6	35.4	47.9	55.8	62.9	61.8	50.0	41.4	26.9	26.0
	Butte	13.8	15.2	29.3	35.5	47.9	55.9	64.1	62.8	50.4	41.9	27.3	24.0
Total Precipitation (Inches of Water)	Deer Lodge	.14	.27	.43	.34	.97	1.07	.15	.67	1.15	.80	1.02	.98
	Drummond	.14	.19	.45	.48	.84	1.59	.06	.48	1.62	.51	1.40	1.25
	Anaconda	.33	.30	.58	.60	.72	.84	1.04	1.22	1.09	1.66	2.42	.94
	Elliston	.23	.21	.63	.88	1.32	1.51	.18	1.85	1.57	.91	1.25	.80
	Butte	.16	.75	.29	.64	.90	2.15	.38	.50	.73	.96	.71	.65

TABLE 1.3

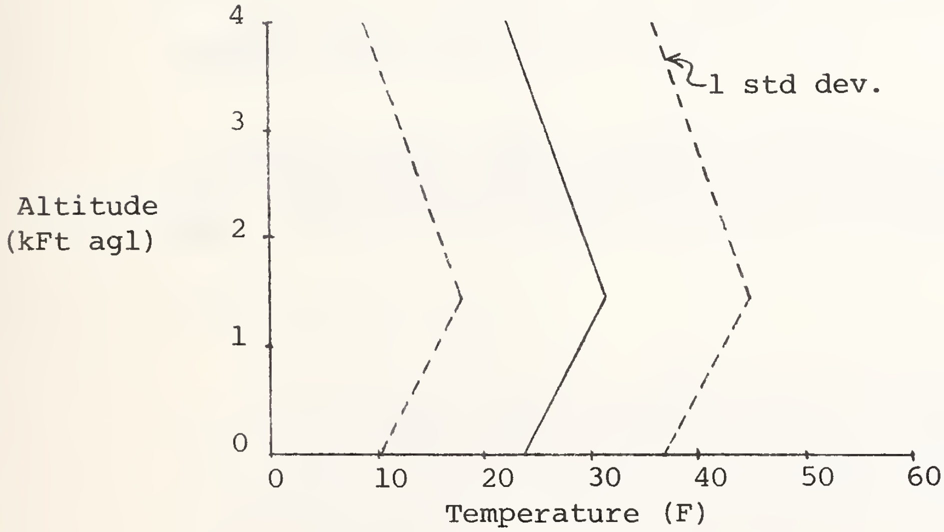
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Normal Maximum Temperature (^{O}F)	Deer Lodge	31.6	36.0	43.2	55.9	64.7	72.0	82.2	80.4	70.2	58.7	42.7	34.1
	Drummond	28.1	33.6	41.5	55.5	64.0	69.8	8.15	79.8	69.9	57.5	40.2	32.9
	Anaconda	29.2	32.8	39.0	49.5	59.5	67.8	79.0	76.9	65.7	53.6	39.5	32.3
	Elliston	30.2	33.5	38.1	50.0	61.1	67.8	79.8	77.6	68.2	55.9	39.1	33.6
	Butte	27.8	32.7	39.1	50.9	60.7	67.9	80.0	78.0	67.5	56.3	40.3	32.5
Normal Minimum Temperature (^{O}F)	Deer Lodge	9.5	12.3	19.0	27.9	35.1	41.7	47.0	44.0	36.7	28.4	19.7	13.4
	Drummond	5.5	9.9	17.0	26.0	33.7	39.5	43.0	41.0	34.3	26.3	16.7	11.6
	Anaconda	14.7	17.0	21.5	39.3	38.1	45.1	52.7	50.9	43.1	34.8	24.8	18.6
	Elliston	8.6	11.4	14.6	25.6	33.6	38.8	43.2	40.7	34.3	26.8	16.9	13.0
	Butte	1.5	5.5	13.7	25.7	33.5	40.1	45.1	42.5	34.8	36.8	1.50	7.7
Normal Mean Temperature (^{O}F)	Deer Lodge	20.6	24.3	31.4	42.0	50.1	57.2	64.1	61.7	52.9	43.1	30.8	23.3
	Drummond	16.9	21.8	29.3	40.8	48.9	54.7	62.3	60.4	52.1	41.9	28.5	22.2
	Anaconda	22.0	24.9	30.0	40.6	49.9	56.4	55.4	54.7	55.4	45.4	31.9	26.4
	Elliston	19.4	22.5	26.4	37.8	47.4	53.3	61.5	59.2	51.3	41.4	28.0	23.3
	Butte	15.1	19.5	26.3	38.5	47.3	54.3	62.7	60.3	51.2	41.6	27.7	20.1
Normal PPN (Inches of Water)	Deer Lodge	.53	.41	.59	.79	1.59	2.31	1.16	.83	1.01	.66	.57	.55
	Drummond	.45	.52	.58	.71	1.99	2.50	1.25	.99	1.19	.81	.70	.61
	Anaconda	.72	.68	.92	.95	1.67	2.48	1.20	.96	1.17	.87	.84	.76
	Elliston	.79	.68	.85	1.50	2.17	2.97	1.27	1.35	1.00	1.03	1.13	.87
	Butte	.42	.44	.65	.90	1.74	2.42	1.20	1.03	1.04	.67	.49	.48

Figure 1.9

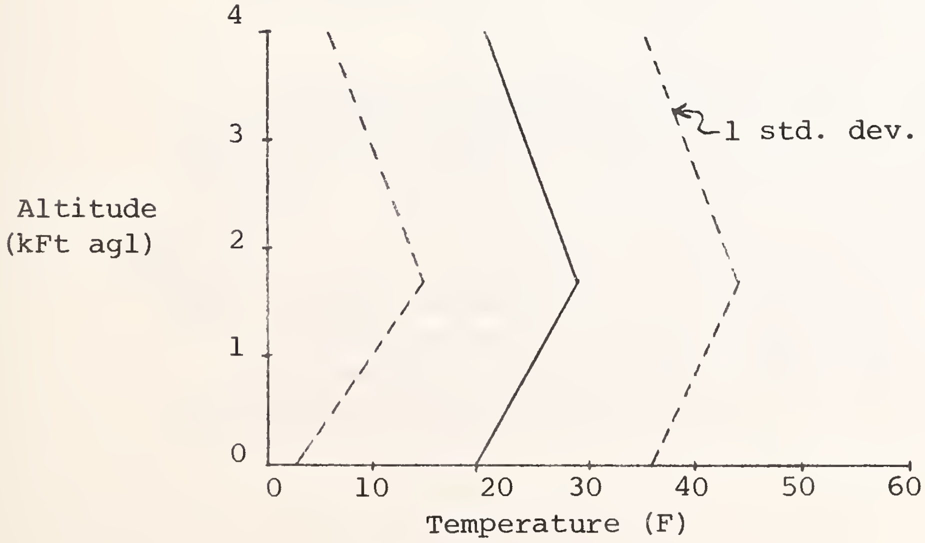
Average Inversion Temperature Profile



Gallatin Field
Bozeman, Montana
October 71 through January 72



Missoula Field
Missoula, Montana
October 71 through January 72



Helena Airport
Helena, Montana
October 71 through January 72

2. SOURCES OF POLLUTION

2.1 Anaconda Area

The major source of pollution in the Anaconda area is the Anaconda Company smelter. The reverberatory furnaces and the converters of the smelter produce about 1214 tons per day of sulfur dioxide. Approximately 492 tons per day are removed prior to discharge into the main stack. The rest of the sulfur dioxide is discharged directly into the main stack or indirectly into the atmosphere. Smaller quantities of sulfur dioxide also emit from the tappings of slag and matte. The main stack of the smelter also releases large quantities of particulates, approximately 31 tons per day into the atmosphere. These particulates are mainly oxides of heavy metals, including zinc, arsenic, lead, copper, etc. Sulfates are also emitted through the stack. A baghouse now under construction will remove an estimated 99% of the particulates from the reverberatory-converter off-gases which contribute the majority of the particulates. The drying operation now performed in one of the roasters releases only small amounts of particulate. Gases from two lime kilns are cleaned of particulate by scrubbers but still emit approximately 20 lbs per hour. Casting furnaces emit combustion gases and only small amounts of particulate. The foundry cupola furnaces operate for only 5 hours in every 10 days. During that operation large amounts of particulates are emitted. Emission rates of 255 lbs per hour have been measured. The smelter is also a source of fluoride but the exact source in the smelter and exact amounts of emissions are unknown (2).

Table 2.1 shows the monthly figures of total copper production by the Anaconda Company (3). Also Figure 2.1 shows the same data only graphed for comparison with monthly air quality measurements taken in the area.

2.2 Butte Area

The Berkeley mine in Butte produces an unknown but significant amount of particulates. The diesel fired vehicles used in the mine area also produce a significant amount of pollutants. Using annual fuel consumption rates for the 135 vehicles operated in the pit area, values in tons per year, for the following pollutants were approximately: sulfur dioxide (573), particulates (102), hydrocarbons (290), oxides of nitrogen (2904), aldehydes (24), organic acids (24) and carbon monoxide (1766) (4).

A second source of pollutants in the Butte area is the Stauffer Chemical Company. The plant has a source of sulfur dioxide in two kiln scrubbing towers which produce about 208 tons per year of sulfur dioxide. The plant also has several sources of particulates. The first, the two kiln scrubbing towers, produces 24 tons per year particulates. In addition to this, there are six turbulaires which release a total of about 48.8 tons per year of particulate. Also one furnace venturi scrubber produces 8.94 tons per year of particulate. The Stauffer Chemical Company plant does emit varying amounts of fluoride but exact emissions are unknown (5). Table 2.2 shows the monthly percent of total production for the Stauffer

Chemical Company (6). Also Figure 2.2 shows the same data on a graph for comparison with monthly air quality measurements taken in the area.

The Butte area ambient air is also contaminated by one tepee burner and three asphalt hot mix plants. The tepee burner produces 15 lbs of particulate per hour. Averaging 8 hours per day and 240 days per year, this source would produce 14.4 tons per year of particulate. The asphalt hot mix plants operate normally just during the summer months. In combination they produce about 100 lbs of particulate per hour.

2.3 Garrison Area

The only major source of pollution in the Garrison area is Rocky Mountain Phosphates, Inc. This plant has two known sources of particulates. The first, the main stack from two natural gas and air fired rotary kilns, produces approximately 2.80 lbs per hour of particulate. The second source of particulate, a natural gas and air fired rotary dryer, produces an unknown quantity as of this time. The main stack from the two kilns also produces some 1.90 lbs per day of fluorides (7). Table 2.3 shows the monthly production figures for Rocky Mountain Phosphates, Inc. in tons of phosphates (8). Figure 2.3 also shows the same data in graph form for comparison with monthly air quality measurements taken in the area.

2.4 Deer Lodge Area

The only significant source of polltuion in the Deer Lodge area is one tepee burner. This burner produces about 25 lbs of particulate per hour. Averaging 10 hours per day and 240 days per year this source would produce 30 tons per year of particulate.

2.5 Philipsburg Area

The Philipsburg area, although not directly in the Deer Lodge Valley, is close enough to be evaluated as a potential pollution source. The Philipsburg area does contain two tepee burners which average 25 and 75 lbs per hour, respectively. Averaging 8 hours per day and 240 days per year, these sources would produce 24 and 72 tons per year of particulate, respectively.

In addition to the sources of pollutants mentioned in the Deer Lodge Valley, some other significant contributors are street and road dust and slash burning. The Forest Service slash burning is permitted by the Board of Health. Burning is restricted to days with good smoke dispersion as forecast by the U.S. Weather Bureau. Burning of this type releases mainly particulates.

Table 2.1

The Anaconda Company
Anaconda, Montana

Monthly Copper Production ~~(millions of~~ pounds)

Month	1971	1972	1973
January	25,156,000	31,079,000	29,265,000
February	26,424,000	29,207,000	27,773,000
March	21,032,000	32,173,000	30,514,000
April	31,180,000	30,248,000	32,040,000
May	31,002,000	32,004,000	35,133,000
June	30,020,000	29,609,000	32,004,000
July	(strike)	29,354,000	32,807,000
August	(strike)	28,988,000	28,986,000
September	4,049,000	28,571,000	23,239,000
October	32,132,000	26,731,000	24,546,000
November	31,065,000	28,469,000	26,096,000
December	33,527,000	29,018,000	32,603,000

Figure 2.1

Anaconda Company
Monthly Copper Production (Millions of Pounds)

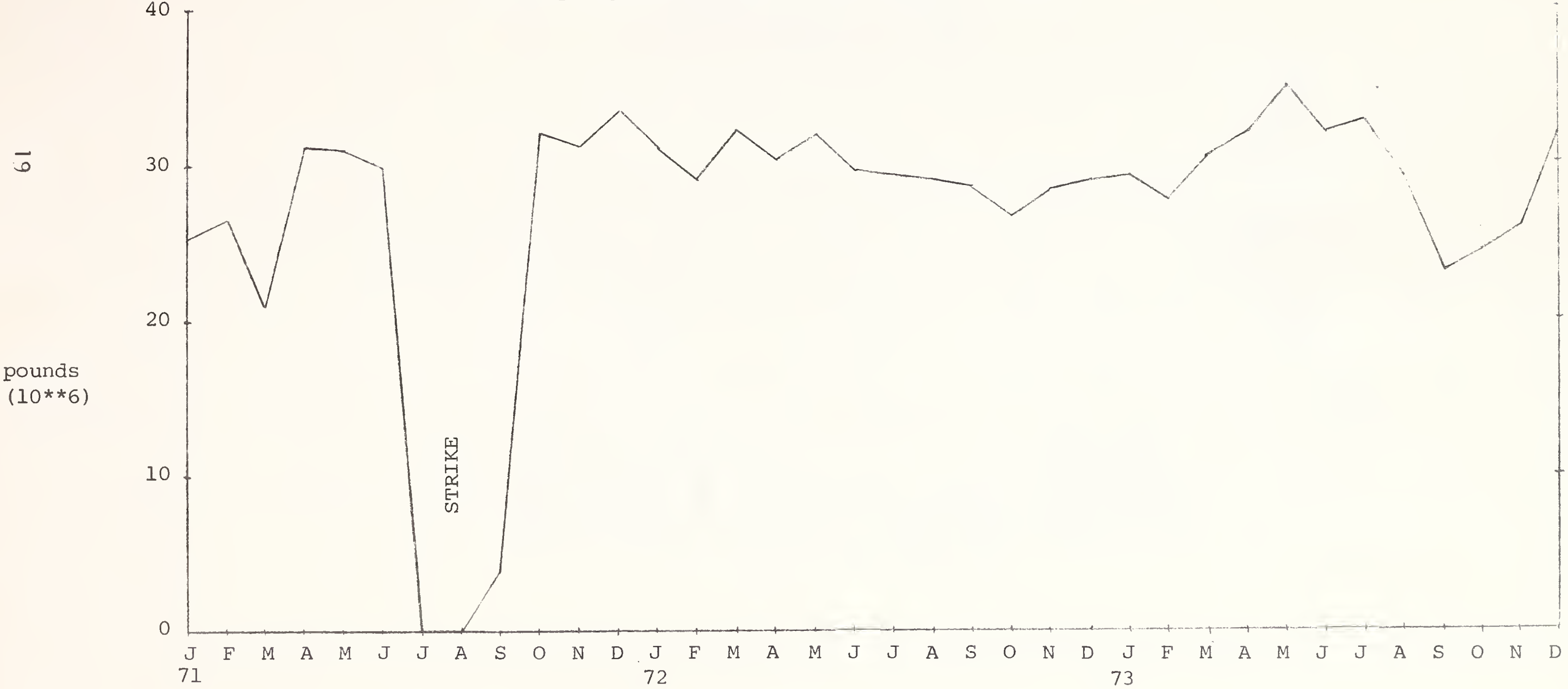


Table 2.2

Stauffer Chemical Company
Silver Bow, Montana
% Production

Month	1971	1972	1973
January	87	78	78
February	100	93	59
March	100	100	100
April	94	100	79
May	95	100	70
June	100	100	59
July	93	70	79
August	91	51	68
September	93	51	89
October	100	51	89
November	91	100	91
December	91	98	71

Figure 2.2

Stauffer Chemical Company
Percent Maximum Production

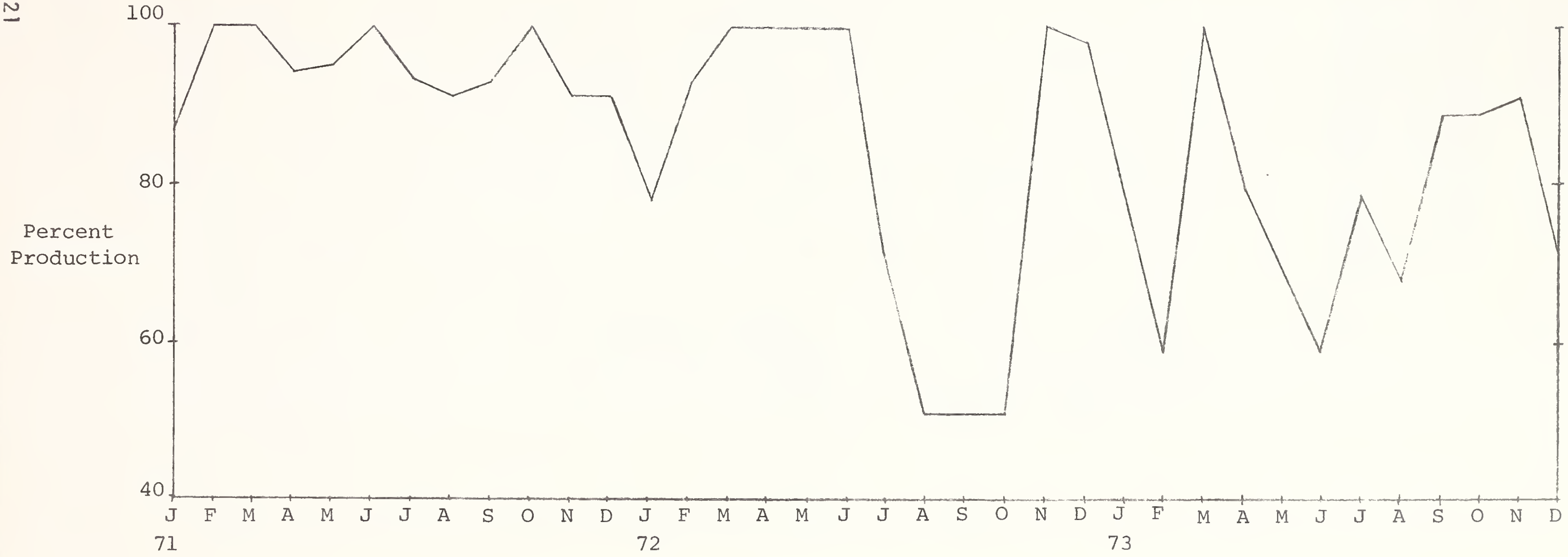


Table 2.3

ROCKY MOUNTAIN PHOSPHATES, INC.

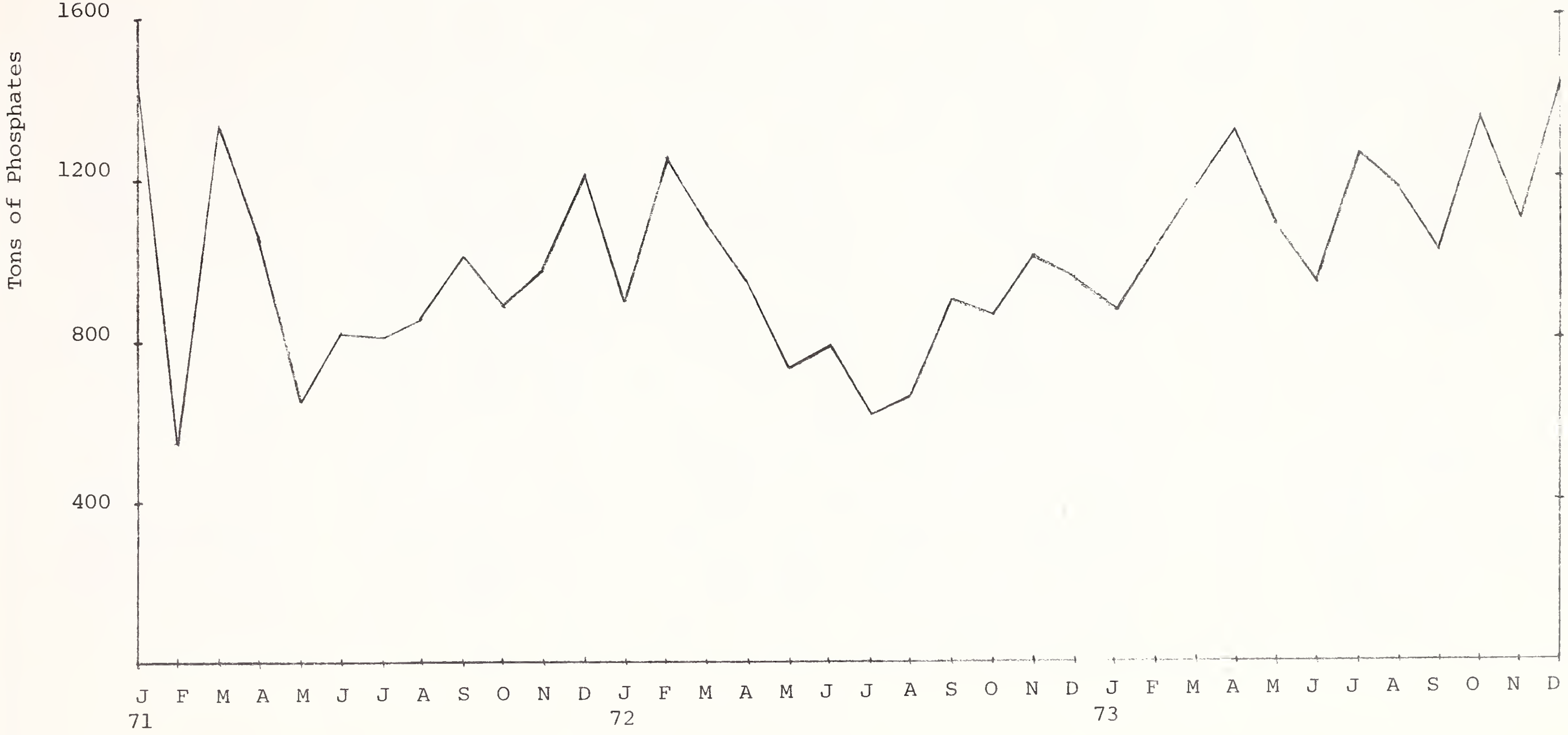
Garrison, Montana

Monthly Phosphate Production (tons)

	1971	1972	1973
January	1460	900	880
February	555	1260	1030
March	1340	1090	1180
April	1060	950	1320
May	650	730	1084
June	820	790	950
July	810	620	1260
August	860	664	1180
September	1010	900	1020
October	890	864	1350
November	980	1010	1100
December	1220	955	1440

Figure 2.3

Rocky Mountain Phosphates, Inc.
Monthly Phosphate Production
(Tons of Phosphates)



3. GENERAL MONITORING TECHNIQUES AND ANALYSIS METHODS

3.1 Background

The revised state implementation plan of June 30, 1972 was written to satisfy federal requirements for the control of air pollution in Montana. Intrastate air quality control regions (AQCR) were defined within Montana's implementation plan. Twelve counties are included within the Helena intrastate region; of these Deer Lodge, Powell, Silver Bow and Granite Counties pertain to this study. Priority classification for the Helena region is shown below.

Helena AQCR Priorities:	Particulates	Sulfur Dioxide	Carbon Monoxide	Oxides of Nitrogen	Hydro-carbons	Oxidants
	I-A	I-A	III	III	III	III

The priority categories I through III depend on pollutant concentrations where the designations I and I-A correspond generally to concentrations well above the national air quality standards. The designation III corresponds to national secondary concentrations or less. Another way of expressing this would be that the priority I is assigned because high pollutant concentrations have been measured or predicted requiring more intensified monitoring, conversely a priority III assignment indicates low ambient levels either measured or predicted. Priorities have been assigned according to highest concentrations recorded at any monitoring station within the intrastate region.

For the purpose of preventing air pollution emergency episodes, priority regions I, II and III (a I-A represents a II priority with respect to emergency episode criteria, otherwise it is a priority I) include contingency plans which shall, as minimum, provide for taking emission control actions necessary to prevent ambient pollution concentrations at any location in such a region from reaching levels which would endanger health. Both I and Ia priorities call for specification of stages equated with increasing pollution concentrations and public announcement whenever any episode stage has been determined to exist. In addition, a I priority specifies emission control actions to be taken by industry and the general public at each episode stage.

Due to the vast spaces in Montana it is difficult for the Air Quality Bureau to obtain immediate concentration readings on monitoring equipment. Therefore, the above emergency episode provisions are rather tenuous.

A minimum amount of ambient air sampling equipment is specified in the state Implementation Plan for the Helena AQCR and is shown below.

Table 3.1

Instrument	Required by Plan	In Use*
high volume sampler	3	6
tape sampler	1	1
SO_2 (continuous)	2	8
SO_2 (bubbler)	3	6
Carbon monoxide	0	0
oxidant analyzer	0	0
nitrogen oxide (cont.)	0	0

*in use as of spring 1974

In 1971 the state maintained some 35-40 sulfation plate stations in the Deer Lodge Valley. Sampling in other areas within the state and additional time demands on state personnel have reduced the sulfation plate sampling in the Deer Lodge Valley to some 12-15 stations in 1974. A similar trend has occurred with fluoride, vegetation and dustfall sampling.

The state in general maintains a minimum sampling network around emission sources using either indicator type sampling devices or well placed continuous monitors. Wind equipment has been set out at some stations.

Table 3.2 lists the sampling devices used in the Deer Lodge Valley study along with some general specifications for the monitoring devices.

Sampling devices originally were placed in high emission areas at varying distances from suspected sources in an effort to isolate that source. As sampling information has been gathered by the state most of the emission sources are now identified, and routine monitoring has been set up at established monitoring sites which historially have given high concentrations of air pollutants. In some cases diffusion modeling has been applied to source emissions to pinpoint geographic areas likely to experience high pollutant concentrations so that monitors can be placed.

Samplers are specifically set out to monitor possible high concentrations in areas where people live. More remote stations are set up to check concentrations in vegetative areas. The state has tried to place sampling stations away from gravel roads and general obstructions, but this has not always been rigorously followed both because electrical power is limited in its availability and because people often live close to graveled roads.

Specific background stations have not been set out for the Deer Lodge Valley. Since the state operates samplers in many locations around the state, some are considered background and can be applied to this study.

3.2 High-Volume Sampler (9)

This sampling device is used to sample suspended atmospheric particulate pollutants. The principal of collection is filtration of suspended particulates - those particles which tend to remain in the atmosphere for extended periods of time. Specific particle size fractions sampled cannot be defined. However, by employing Stoke's law and using average gas velocity, it can be found that this type unit, housed in a shelter will sample under quiescent conditions particles to 100 microns in diameter having a specific gravity of 2.65 and average velocity of 64 feet per minute across the horizontal air inlet portal of the shelter. Wind will upset this relationship and allow collection of larger and heavier solids.

A typical hi-vol is shown in figure 3.1. A specifically housed vacuum sweeper motor pulls air through a glass fiber filter which offers high filtering efficiency for submicron particles with minimum pressure drop throughout the sampling period and limited water absorption from the air.

Prior to use, each filter is serialized and precision weighed under laboratory conditions. The filter is shipped to the sampling site where ambient air is drawn through it for 24 hours. A calibrated field-type rotameter reading is made before and after the 24-hour sample is taken.

Table 3.2

Monitor or Parameter	Units	Sampling Time	Substance Measured	Analysis
High-Volume Sampler (total suspended part.)	ug/m^3	24-hr.	particles* 0.01u- 100u	chemical & gravimetric
Dustfall Bucket (settled particulates)	tons/mi^2	monthly	particles* abt. 50u on up	gravimetric
Membrane Sampler	ug/m^3	24-hr.	particles* 0.01u - 50u	chemical
Tape Sampler	coef. of haze	cont.	particles* 0.01 - abt. 30u	light transmission
Nephelometer	Miles	cont.	0.01u - 2u	light scattering
Cascade Impactor	ug/m^3	24-hr.	particles* 0.01u - 50u	gravimetric
Sulfation Plates	mg SO_3/100 cm^2/day	monthly	gaseous sulfur compounds	turbidimetric
Sulfur Dioxide Monitor	ppm	continuous	SO_2	coulometric
Fluoride Paper	ug F^-/cm^2/ 30 day	monthly	gaseous fluoride	chemical
Fluoride Plate	ug F^-/cm^2/ 30 day	monthly	gaseous fluoride	chemical
Vegetation	ppm	monthly to seasonal	fluoride/metals	chemical

*particle sizes shown here are approximate

ug/m^3 = micrograms per cubic meter of air
u = microns
ppm = parts per millions of air

Note: a human hair is approximately 30 microns in diameter

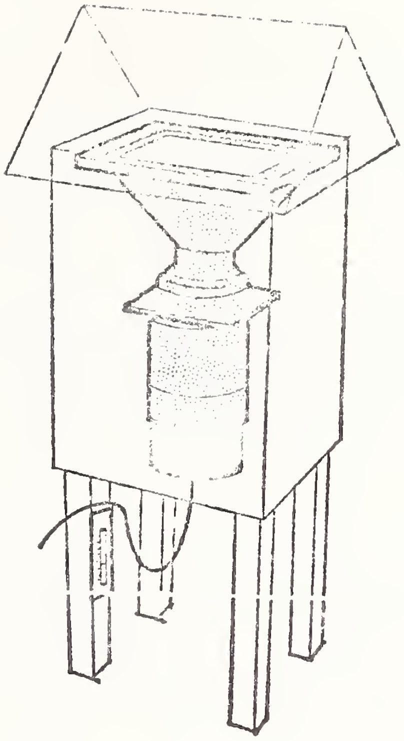


Figure 3.1 High-Volume Particulate Sampler

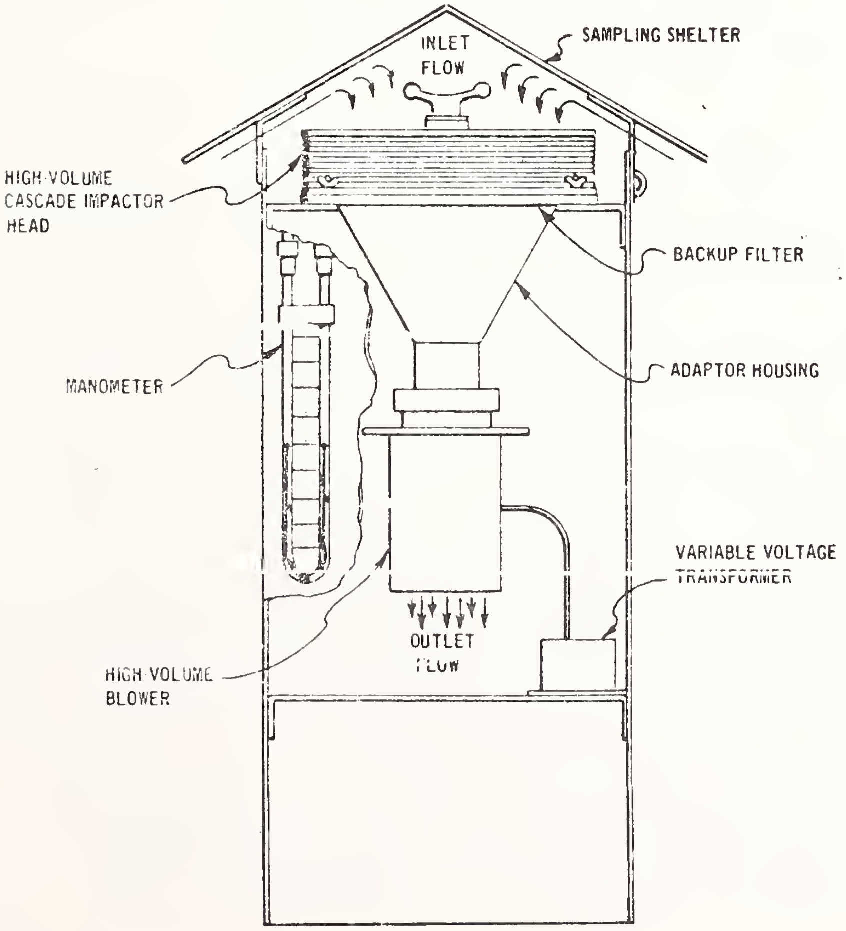


Figure 3.2 High-Volume Cascade Impactor
with Backup Filter for Sampling Atmospheric Aerosols

The average of these two cubic foot per minute rates is used to find the total volume of air which has passed through the sampler. The filter is returned to Helena where it is equilibrated at laboratory conditions before a second precision weighing is made. This difference in weight along with the volume of air drawn through the device in 24 hours gives the total suspended particulate loading in micrograms per cubic meter of ambient air.

The primary advantage of the hi-vol is that it will sample a large volume of air in a relatively short period of time. Disadvantages include substance original costs followed by fairly high filter, operating and analysis costs. Electrical service must also be obtained, which limits sampler location.

3.3 Membrane Sampler

The membrane sampler collects total suspended particulate matter as do the hi-vol and impactor samplers. Since the air flow is approximately 3 to 4.5 cubic feet per minute the shelter inlet air flow through the shelter differs from that of the hi-vol and impactor in that the lower flow rate aerodynamically draws in lighter particles.

A large puller motor is needed to overcome the increased flow resistence of the cellulose membrane filter material which is 10 cm in diameter.

The sampler is used because the membrane filters do not in general contain the trace metal contamination associated with the fiberglass filters. The total membrane filter can be digested in acid during the sample preparation allowing for better chemical detection of trace elements than fiberglass filters.

There are some flow problems associated with these filters since cellulose tends to pick up and retain moisture.

3.4 High-Volume Particle Fractionating Cascade Impactor (10)

The high-volume particle fractionating cascade impactor, manufactured by Anderson 2000 Inc. is a multistage, multijet unit consisting of five aluminum jet plates separated by sized neoprene rubber gaskets (Figure 3.3). The plates are backed by a standard 8 by 10 inch hi-vol filter to collect submicron particles. Each plate is approximately 12 inches in diameter and contains approximately 300 sized jets. The alignment of the 12-inch plates and resulting air flow patterns direct the particle onto the surface of the jet plate below. The collection surface is covered with a cut and perforated fiber-glass filter which has been preconditioned and weighed. The size and location of the jets are held to very close quality control tolerances to give proper fractionation. The collection medium contains punched holes so that it does not obstruct the jet openings in the plates. The head interface plate contains four dowel pins and a center post for properly locating the jet plates with respect to each other and for aligning the collection medium with the jet plates. The assembled head is positioned on a 9 by 11 inch interface gasket and attached to a conventional hi-vol filter holder inside the hi-vol shelter (Figure 3.2). A standard hi-vol

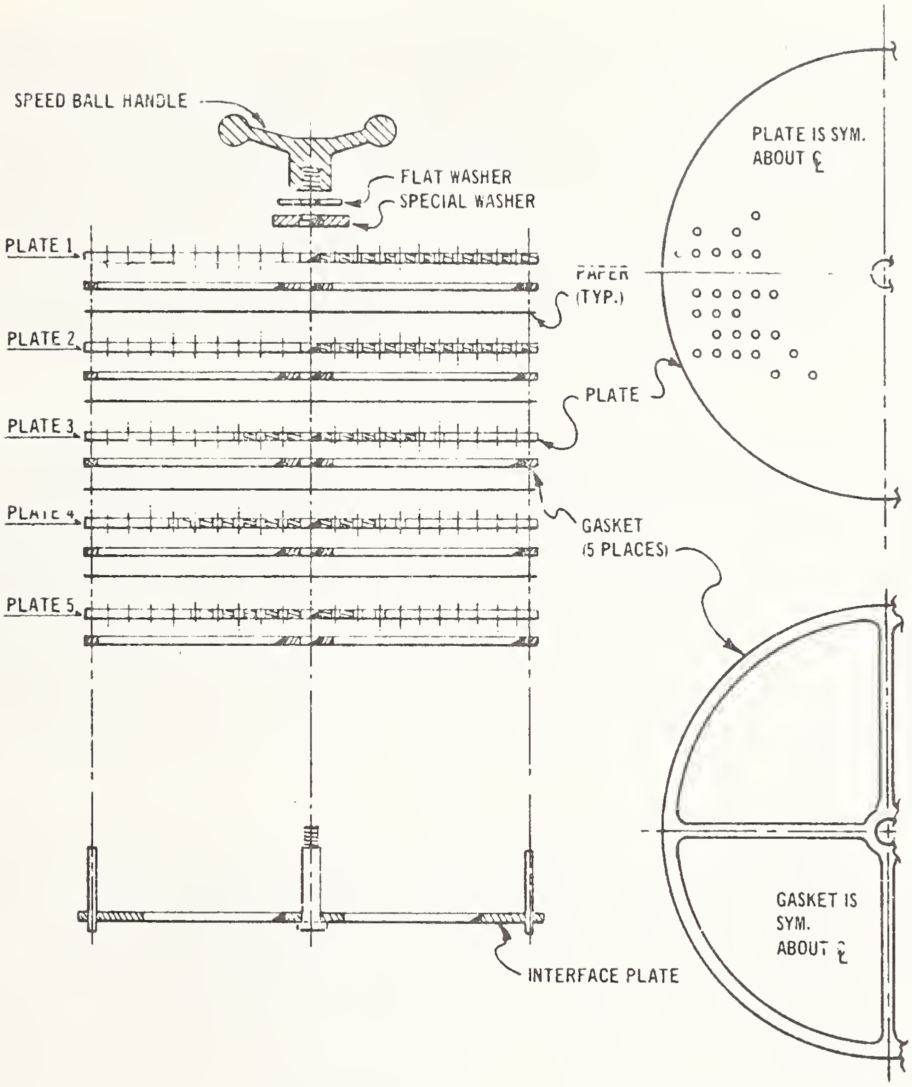


Figure 3.3 High-Volume Fractionating Sampling Head for Cascade Impactor

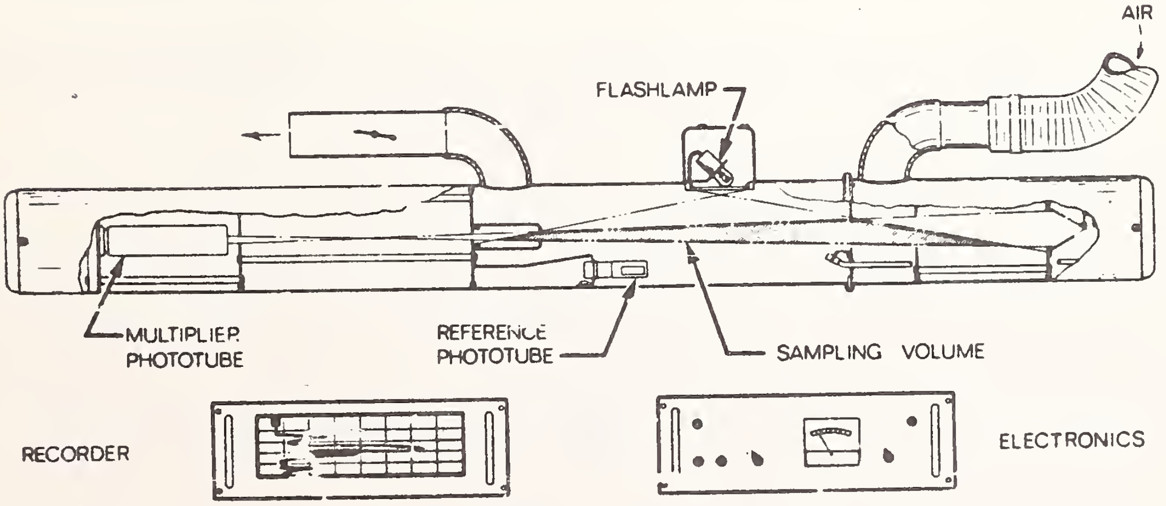


Figure 3.4 Mechanical Assemblies of an Integrating Nephelometer

air mover is used for air flow through the system. The aerodynamic separation of the five plates allows the collections of: 7.0 microns(u) and above, 3.3-7.0u, 2.0-3.3u, 1.1-2.0u, and 0.1-1.1u. Regulation of the air flow through the fractionator is achieved by adjusting a variable voltage transformer and noting the corresponding pressure drop through the assembled fractionator as indicated by a manometer. For proper fractionation and sizing, the fractionator should operate at 20 ft^3/min. Since the fractionator collects the major portion of samples, and especially the large particles, the flow rate will remain constant except for minor line voltage fluctuations.

3.5 The Dustfall Jar (11)

Basically the dustfall bucket may refer to a variety of open top cylindrical containers. This device is an open topped container into which the larger and more dense fraction of atmospheric pollutants may settle. The state has in general standardized on simlar shaped plastic containers with screw-on lids for transporting to the laboratory. A fairly large jar with restricted mouth is used to prevent particles from becoming re-entrained into the ambient air by wind. To facilitate retention of particles deposited therein, water with either an algicide for summer usage or anti-freeze in winter months can be used.

The sampling procedure is to place an open-mouth container high on a pole and away from buildings or other structures which would interfere with fallout of particulate from the atmosphere. The container is then left for one month, after which the sample is returned to the laboratory. The amount of settleable particulate is then determined gravimetrically on an analytical balance. The sample can also be used to determine individual chemical constituents if desired. The grams of particulate per area exposed is then converted to tons/mi^2/mo. Local conditions such as dusty roads can cause results to vary widely. Interferences such as leaves, twigs and bird droppings also affect results and are partially removed by screening the sample before weighing.

"Replicate samples by various investigators indicate a precision of ± 15% is attainable for any given combination of collecting element and retention fluid. Results of greater than 2 to 1 variation have been found with replicate samples taken by different methods (12)." Thus the method is not precise.

It is, however, simple and inexpensive giving an indication of the amount of settleable particulate in a given area.

3.6 Particulate Tape Sampler (13)

The tape sampler is an automatic device developed to evaluate soiling potential of the ambient air and visibility qualities of the ambient atmosphere. The principle components of the tape sampler are vacuum pump, sampling nozzle, automatic time and sampling tape. The vacuum pump draws the ambient air containing suspended particulates through a cellulosic tape filter held in the sampling nozzle. The particulates are deposited upon the tape. At predetermined intervals the tape is advanced automatically to a clean area where another sampling period is begun. As many as 600 sample spots may be collected on the 100 foot rolls of filter tape.

The sampling period may be selected by setting the desired interval on the automatic timer. The time sampler may be set for as long as 3½ hours per spot. The tape sampler operated by the Montana Department of Health and Environmental Sciences at the Harrison School in Butte was operated in 3 hour segments. The sampling period per spot is limited to a maximum of 2 hours in most cases to prevent an excessive buildup of particulate material.

The rate of flow of sample air through the instrument may be approximately 7 liters or 0.25 cubic feet per minute. The diameter of the sample spot is one inch.

The optical density or "dirtiness" of the spot is related to the volume of air passing through the device and the amount of particulate matter in the air. It is necessary that the unit be flow-calibrated prior to being placed into service and at appropriate intervals to assure the reliability of the data. This usually is done with a wet test meter as the standard metering device.

The spots of deposited material upon the sampling tape are evaluated on the basis of how much light they transmit. The evaluation is done with the aid of an automatic transmissiometer through which the tape is passed for consecutive evaluation of the spots.

The readout is onto a strip chart and is in terms of optical density or darkness of each spot. The analytical results for the tape sampler are reported in terms of COH's per 1000 linear feet. The COH designation stands for coefficient of haze. This is defined as "the quantity of light-scattering solids producing an optical density of 0.01 when measured by light transmittance."

$$\text{Optical density} = \log \frac{I.00}{I \text{ measured}}$$

where:

I/is the intensity reading without interfering particles present (usually selected as 100)

I measured is the intensity reading with interfering particles present (always less than 100)

A sample calculation is:

average sampling rate = 0.3 cfm

Sampling time = 100 min.

I measured = 50

Diameter of tap spot = 1.0 in.

$$\text{Volume sampled} = 100 \text{ min} \times 0.3 \frac{ft^3}{min} = 30 \text{ ft}^3$$

$$\text{O.D.} = \log \frac{I\ 100}{I \text{ measured}} = \log \frac{100}{50} = \log 2 = 0.301$$

$$\text{COH's} = \frac{0.301}{0.01} = 30.1$$

Several soiling index rating systems are in existence. One such system is as follows:

COH/1000 lin. ft.	Rating
0-0.9	light
1.0-1.9	moderate
2.0-2.9	heavy
3.0-3.9	very heavy

3.7 Integrating Nephelometer (14)

The integrating nephelometer is comprised of two major assemblies. The first is the sensor unit consisting of the optical assembly with its calibrator, flashtube and two phototubes together with its associated air sampling equipment including ducts, filters and pumps. The second part is the electronic control module containing the necessary amplifiers, power supplies and an indicating meter for monitoring the output from the instrument.

The mechanical assembly is made in a four-inch diameter aluminum tube approximately 44 inches long. The general layout is shown in Figure 3.4. The flash lamp behind its opal glass screen is mounted on one side of the tube. The multiplier phototube is located in one end of the tube and detects the scattered light from the illuminated volume. The light trap and calibration mechanism are situated in the other end.

The reference phototube is mounted in the chamber containing the air volume to be measured. The gas to be sampled is drawn into the sampling chamber through an intake duct with the air movement being provided by a vacuum blower mounted in the outlet ducting, moving approximately 10 cubic feet of air per minute. This flow rate is not critical and the nephelometer output is independent of it.

The primary scale of the nephelometer is that of scattering coefficient. It is calibrated in units of reciprocal meters (m^{-1}) with Freon-12 having the value of 3.6×10^{-4} m^{-1}. The secondary scales are for meteorological range and mass concentration.

The meteorological range (Lv) scale is based on the Koschmieder visibility theory stateing that:

$$Lv \simeq \frac{3.9}{b_{550}}$$

The relationship between the scattering coefficient at 550 nm, b_{550}, and that at 500 nm, b_{500} is:

$b_{500} \simeq 0.84$ $b_{500} \simeq 0.84$ b_{scat} = b_{500} is the quantity indicated by the instrument so that:

$$Lv\ (m) \simeq \frac{4.7}{b_{500}} = \frac{4.7}{b_{scat}}$$

The meteorological range scale is based on a large number of experiments relating light scattering, mass concentration and visual range as well as the correction factors discussed above. The best current value for the relationship of meteorological range and mass concentration is:

$$L_v \times \text{mass} = 1.8 \text{ g/m}^2$$

In order for the units of this expression to come out correctly, L_v is put into meters and mass concentration into grams per cubic meter. This quantity represents the mass of material in a box one meter in cross section and of length L_v. This can be restated in more convenient units where mass represents mass concentration:

$$\text{Mass} = \frac{1.8 \times 10^3}{L_v \text{ (km)}} \quad (\text{ug/m}^3)$$

Alternatively, the relationship between light scattering coefficient, b_{scat}, as indicated by the primary scale and mass concentration is:

$$\text{Mass (ug/m}^3) = 3.8 \times 10^5 \, b_{scat} \, (\text{m}^{-1})$$

It is important to state very clearly that the nephelometer measures only light scattering and not mass concentration or visual range. However, the published relationships between these two quantities and scattering are certainly useful and are therefore given as secondary scales.

The absolute accuracy of the integrating nephelometer is somewhat difficult to estimate since there is no other instrument for comparison. Studies of the correlation of nephelometer output with visual range as well as theoretical considerations suggest that the calibration is correct to within ± 10%. However, the relative accuracy is perhaps more important since it governs the reproducibility of the measurements. Absolute accuracy cannot affect reproducibility since it is controlled by systematic errors. The relative accuracy is governed by the signal-to-noise ratio which is typically about 20-50 for scattering by city air. Thus, the overall relative accuracy should be about ± 2 to 5%.

3.8 Sulfur Dioxide (15)

The sulfur dioxide (SO_2) measured in the ambient air in the Deer Lodge Valley was measured by the Beckman Model 906 A sulfur dioxide analyzer. This analyzer continuously measures the concentration of sulfur dioxide in ambient air drawn through the analyzer, and provides meter indication of the results. Principles of secondary coulometry and dynamic iodimetric titration are employed to achieve reliable measurements in ranges from twenty parts per billion to four parts per million. Response time is independent of sample concentration.

The analyzer uses a detector cell containing a platinum anode, a platinum cathode, and an activated carbon paste reference electrode. All three electrodes are immersed in a buffered halide electrolyte circulated continuously within the detector cell. A constant-current source for the detector cell generates iodine continuously by anodic oxidation of the iodine at the anode and reduces the iodine thus formed to iodide ion by cathodic reduction at the cathode. During operation of the analyzer, an equilibrium concentration of iodine in the detector cell provides reaction capability for detection of sulfur dioxide.

As ambient air is drawn through the detector cell and swept through the electrolyte, the sulfur dioxide component undergoes hydrolysis in the electrolyte. The hydrolysis product acts as a chemical reductant to the steady-state concentration of iodine in the cell, and causes a decrease of iodine level. This results in an electrochemical imbalance in the detector cell because there are insufficient iodine charge carriers present to transport the current being supplied to the detector cell by the constant-current source. Consequently, a fraction of the current applied to the detector cell--an amount related to the extent of electrochemical imbalance--is forced to flow through the reference electrode, thus completing a circuit through the detector cell.

The amount of current flow through the reference electrode is related directly to the concentration of the sulfur dioxide component in the ambient air sample. Current flow through the reference cell is measured and amplified to drive the meter.

3.9 Sulfation Plates (16)

The sulfation plate for determining SO_2 concentrations is made by attaching a 4.8 centimeter diameter Gelman A fiberglass filter to a 4.8 centimeter diameter petri dish with three drops of acetone. The lead dioxide solution to coat the petri dish is made in the following manner: 112 grams of lead dioxide is blended in a blender with 700 millimeters of water, 0.7 grams of gum tragacanth, and 7 grams of fiberglass filter ground on a Wiley mill to pass 20 mesh. Ten milliliters of this material is transferred into each petri dish. The coated dish is dried in an oven at low temperature (60°C) and sealed with a lid.

To expose a sulfation plate, the lid is removed and the plate is placed in a bracket that will secure the sulfation plate upside-down. (Figure 3.6) The petri dish serves as the shelter, shipping container, and lead dioxide support. The sulfation plate is exposed for approximately 30 days.

After exposure, the lead dioxide is removed from the petri dish with a little water. The insoluble lead sulfate is converted to soluble sodium sulfate with the aid of 20 ml of sodium carbonate solution (50 grams/liter) and heat. The excess insoluble lead dioxide is removed by filtration. The solution is acidified with hydrochloric acid to bring the pH of the filtrate between 2 and 3. The acidified filtrate is diluted to 50 ml or any other convenient volume with water. A portion of this solution (up to 25 ml) is then siluted with 25 ml of water. To this, 0.1 gram of sulfaver powder is added, mixed, and let stand 20 minutes. The resulting turbidity is measured in a spectrophotometer at 450 millimicrons.

3.10 Sodium Formate Plates (12)

This sampling technique is used to measure monthly levels of fluoride in the air. The fluoride collection media used is a Whatman 41 filter paper (4.7 cm diameter) attached to a petri dish with three drops of acetone.

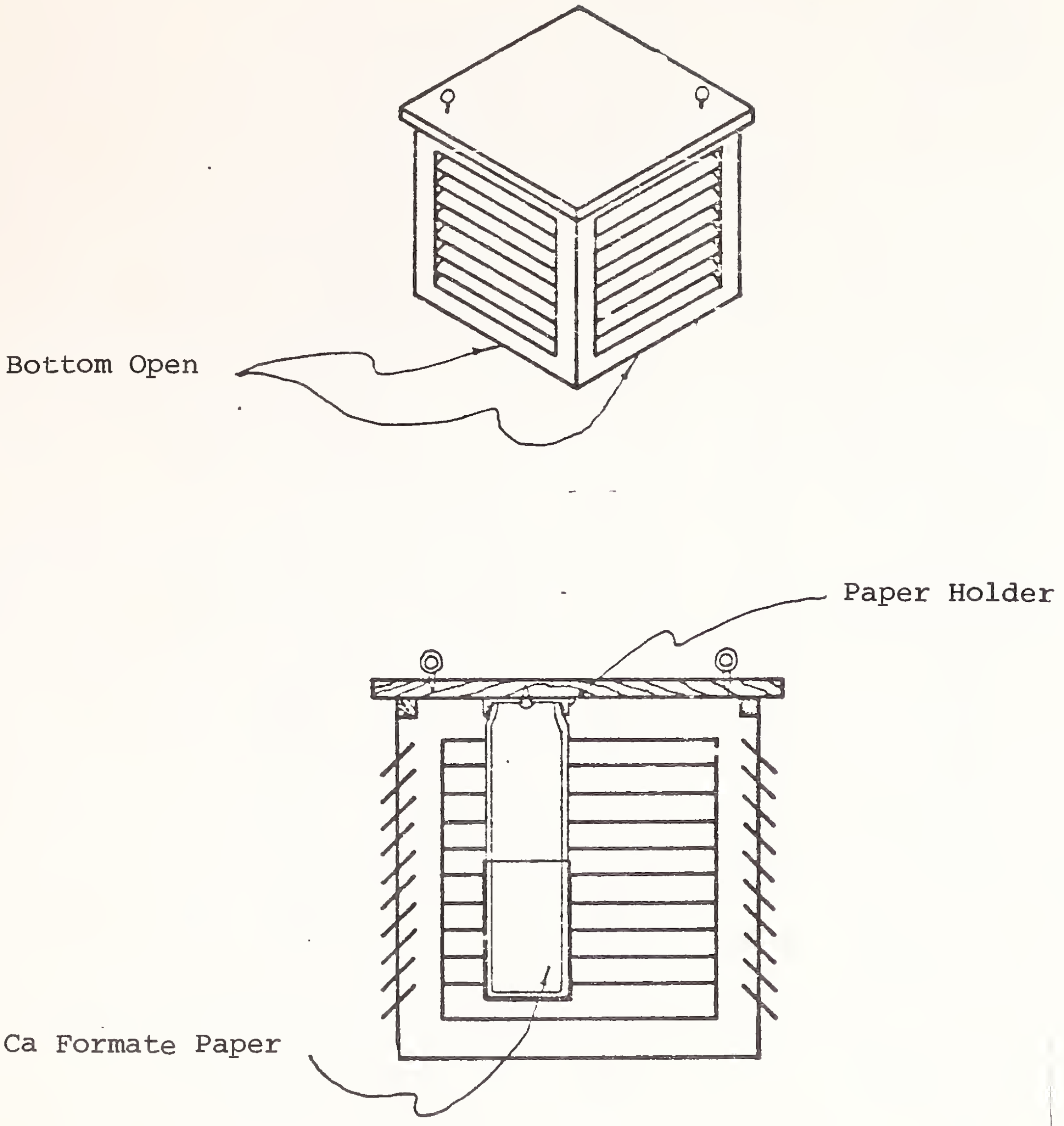


Figure 3.5 Montana Box For Holding Ca Formate Papers for Sampling Fluorides in the Air

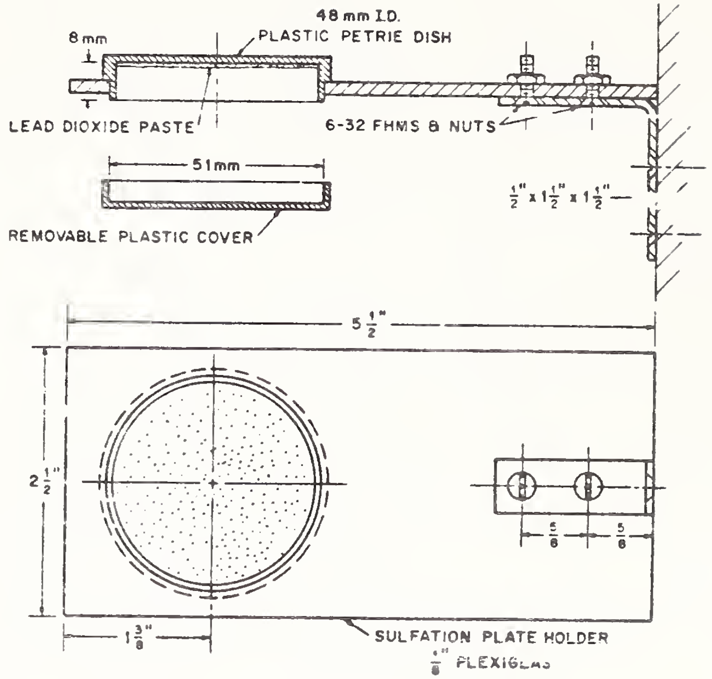


Figure 3.6 Holder for both Sulfation Plate and Na Formate Plate Samplers.

The filter discs are immersed in a 50% ethyl alcohol solution containing 10% sodium formate. These discs are air dried at room temperature in a fluoride free area.

To expose the fluoride plate, the lid is removed and the plate is placed in a bracket that will secure the sulfation plate upside-down (Figure 3.6). The petri dish serves as the shelter, shipping container, and lead dioxide support. The sulfation plate is exposed for approximately 30 days.

The exposed filter paper is removed from the petri dish and placed in a 100 ml polyethylene beaker. The filter paper is covered with 20 ml of distilled water and let stand for 2 hours. Next 20 ml TISAB buffer solution is added and the fluoride concentration is read on the fluoride electrode as the solution is stirred with a magnetic stirrer.

The range of measurement of the fluoride electrode is .019 to 19,000 ppm soluble fluoride. However, the recommended range of analysis for air samples is between 0.1 and 10 ppm.

3.11 Calcium Formate Papers (12)

Ambient air samples for fluoride are collected with the use of filter paper impregnated with calcium formate. The 11 centimeter filter papers are prepared by soaking Whatman No. 2 papers in a solution of 10% calcium formate (10 grams calcium formate dissolved in 100 ml distilled water) for approximately 5 minutes and drying them in a forced air oven set at approximately 80 C for about one hour or letting them dry overnight in a room free of fluoride.

The filter papers impregnated with calcium formate solution are exposed in a standard louvered shelter (Montana box) for approximately 30 days. (Figure 3.5) The shelters give protection from normal rainfall and snow, while permitting free flow of air over the papers. They are installed about 2 meters above the ground, clear of shielding objects.

After the papers have been exposed for approximately 30 days, they are fired in inconel crucibles in a muffle furnace for approximately one hour at 600C. The ashed papers are dissolved with 100 ml of 1-1 $HClO_4$ and diluted to 250 ml with distilled water. Using the auto-analyzer, the solution and sulfuric acid are pumped into the Teflon coil of a microdistillation device maintained at 170 C. A stream of air carries the acidified sample swiftly through a coil of teflon tubing to a fractionation column. The fluoride and water vapor distilled from the sample are swept up the fractionation column into a condenser and the condensate passes into a small collector. The distillate is pumped continuously from the sample collector. Acid and solids are removed from the bottom of the fractionation column and are drawn to waste. The distillate is mixed continuously with alizarin fluorine blue-lanthanum reagent, and the colored stream passes through a 15 mm tubular flow cell of a colorimeter, where transmittance is measured at 620 mu. The impulse is transmitted to a recorder.

This method can detect values as low as 0.1 ug F/ml. The operating range of the recorder is 0.1-2.0 ug F/ml. Higher concentrations must be diluted with a 1 to 1 solution of $HClO_4$.

3.12 Fluoride in Vegetation (12)

Fluoride measurements in vegetation were taken mainly from grass samples. Grass is cut with scissors, not closer than 1½ inches to the ground. The samples should be taken from as near the same spots as possible from one period to the next to get maximum collection of fluoride values for different periods. Samples are placed in clean containers for transportation to the laboratory.

The grass samples are dried in a forced air drying oven for 24 hours at about 100 C. After drying, these samples are ground on a Wiley mill until they pass 40 mesh. Samples of 0.5 grams are weighed into inconel crucibles which is added 10 ml of a solution of calcium formate containing 50 grams per liter of calcium formate. The mixture is stirred until the liquid is well mixed with the sample and the sample is then dried in a forced air oven at 100 C. After drying, the samples are fired in the müffle for approximately two hours at 600 C. The ashed samples are fused with 3 grams of sodium hydroxide at 600 C for 3 minutes. The fused samples are dissolved in 20 ml of 1-1 HCLOv and diluted to 50 ml with distilled water. The samples are placed in the auto-analyzer carosel.

The suspended digest and sulfuric acid are pumpted into the distilled and fractionated in the same manner as the calcium formate papers.

This method can detect values as low as 0.1 ug F/ml. The normal detection range is 0.1-2.0 ug F/ml. Higher concentrations **should** be diluted with sodium hydroxide and perchioric acid mixture.

3.13 Validation of Data Anomalies

The following is a general list (by pollutant) used to verify that a sample is in excess of state and/or national air quality standards.

Hi-Vol

1. EPA publication R4-73-028b (June, 1973) titled Guidelines for Development of a Quality Assurance Program is followed.

2. In general if a high reading is noted as data sheets are prepared for key punching the following procedure is used. From the laboratory and serial numbers assigned to each filter, the weighing arithmetic is checked, the filter is again observed and the field sheet which is filed with the filter is reviewed for flow readings and sample time and general filter appearance as well as environmental documentation unique to the 24-hour period during which the sample was taken is reviewed. The previous calibration card is pulled for the hi-vol in question and reviewed. Field, clerical and laboratory people who routinely handle the machines, documents and filters are consulted as necessary.

3. Initially sites are established for each monitor to attain representative samples as per generally acceptable sample locations.

4. As for data processing, the state keeps permanent records, uses electronic calculators, transcribes concentrations only once between initial and final tabulations, validates keypunching and uses state data processing facilities.

Tape Samplers

1. For high particulate readings the strip chart is checked for previous calibration, for base-line drift, for inlet sample air flow and for correspondence to time marks made by the operator on the strip chart. The log book is reviewed and data from adjacent hi-vol samplers is observed.

Sulfur Dioxide Continuous Monitors

1. High SO_2 levels are first observed as the strip charts are read either by the operator or by a data clerk.

2. Previous unadjusted zero, adjusted zero and calibration points are reviewed. In some cases daily to weekly span points are made for checking the zero and calibration points.

3. If the operator observes unusually high readings in progress, he performs zero, span and response checks on the instrument as soon as the readings subside or during the reading if he decides this is necessary.

4. Log books unique to the monitor are reviewed along with quarterly multipoint detailed calibration information. Recorder function and electronic spanning as well as electronic function of the analyzer are all considered.

5. Plus and minus limitation as to sample air flow and base-line drift are considered.

6. Accompanying wind equipment readings are checked for wind directions and speed from the pollution source to the monitoring site.

7. Only certified permeation tubes or span gases are used.

8. Wet chemistry standardizations are checked for ultimate calibration against permeation tubes precisely regulated for flow and temperature.

4. PRESENTATION OF DATA

Summaries of measurements of total suspended particulates, trace elements in particulates, settleable particulates, sulfur dioxide, sulfation rate, and fluorides are given in this section. Sampling sites for the various pollutants measured are presented in Appendix II.

Table 4.1 is a statistical summary of the total suspended particulate measurements taken in the Deer Lodge Valley. Geometric means were calculated instead of arithmetic means in order to relate values to the Montana and Federal air quality standards. In comparisons of the number of days data gathered and the number of days that it could have been gathered, one must take into account that high-volume samplers were run one day in every three or six days. Therefore, the number of days possible should be adjusted by the frequency of sampling. Operational periods of the samplers are given for the individual sites. Table 4.2 shows the number of times standards for TSP were exceeded. Figure 4.1 shows a comparison of annual geometric means and maximum 24-hour averages. Montana air quality standards are shown as dashed lines. Figures 4.2 through 4.4 show monthly trends of total suspended particulates for various stations in the valley. Table 4.3 shows a comparison of pollutant levels for 1961-62, 1965-66 and more recent values. Values are for the geometric mean and the geometric mean plus the geometric standard deviation. Where no geometric standard deviation is given, only one measurement was taken that month. The result of trace element analysis performed on some of the high volume filters is given in Table 4.4. Analyses are shown for arsenic, lead, cadmium, and zinc.

Table 4.5 presents a seasonal summary of settleable particulates (dustfall) as measured in the valley. Values are also presented for the Philipsburg area even though the town is not located directly in the Deer Lodge Valley. Certain values are footnoted as containing only one or two readings in that season. Figures 4.5 and 4.6 present monthly trends of dustfall measurements for some of the longer duration sites. Standards given are for 3-month periods.

Table 4.6 presents a statistical summary of sulfur dioxide (SO2) data measured from continuous analyzers. The number of individual readings taken and the number of readings possible are given. Before quarterly or yearly statistics can be considered valid for the National Air Data Bank (NADB), 75% of the individual readings must be present (17) The total sulfur dioxide measured is also given along with the operational periods. Table 4.7 summarizes the number of times the Montana and Federal air quality standards were exceeded as detected by computer from the raw monitoring data. Table 4.7 also shows the distance and direction from the main stack for each of the analyzers. Figure 4.7 shows a comparison of the various SO_2 sites for several different averaging times. Figure 4.8 through 4.11 show trends of sulfation rate as measured at some of the longer duration stations.

Figures 4.12 through 4.18 and the lower half of Figure 4.19 show monthly trends of fluorides as measured by Ca Formate papers. The

Montana air quality standard of 0.3 micrograms per square centimeter per 28 days is included as a reference. Figures 4.17 and 4.18 include the standard of 100 ug $F^-/cm^2/30$ days for ponds. Figures 4.19 (upper half) and 4.20 also show fluorides in the air as measured by Na Formate plates. The Montana standard for Ca Formate papers is added to the figures for Na Formate plates even though the standard is specifically for Na Formate plates. This is done for a point of reference for comparison with Ca Formate paper results.

Table 4.8 shows fluoride levels measured in vegetation collected around Rocky Mountain Phosphates, Inc. Values are given as seasonal averages. Monthly maximums and minimums and dates of operation are also shown. Figures 4.21 and 4.22 show the monthly trends of fluoride in vegetation collected around Rocky Mountain Phosphates, Inc.

Table 4.1

TOTAL SUSPENDED PARTICULATE DATA FROM HIGH VOLUME SAMPLERS FROM THE DEER LODGE VALLEY AREA

January 1971 - December 1973

Site	Geo. Mean (ug/M^3)	Geo Std. Dev. (ug/M^3)	Max 24-hr (ug/M^3)	No. Days Data	No. Days Possible*	Operational Period
Anac. Jr. High Anaconda	48	11	249	119	425	2/71--3/72
Kirkeby Anaconda	43	10	208	75	244	4/72--11/72
Bailey's Res. Deer Lodge Co.	36	7	93	7	61	10/71--11/71
Kucera's Res. Deer Lodge Co.	20	7	89	52	213	12/72--6/73
S & N Cement Deer Lodge Co.	48	5	53	2	31	10/71
Johnson Res. Deer Lodge Co.	49	34	235	31	183	3/71--11/71
Atkin's Res. Butte	32	2	168	47	214	6/73--12/73
Courthouse Butte	74	44	381	84	332	2/71--11/71 2/72
Greely School Butte	95	34	371	76	333	2/71--11/71 2/72--3/72 (except June)
Harrison Fire Sta Butte	93	32	483	48	213	7/71--11/71 2/72--3/72
McQueen's Add. Butte	194	152	528	7	30	4/72
Old Emerson Sch. Butte	92	7	282	40	212	1/71--7/71
Silver Bow Hosp. Butte	75	12	402	46	213	7/71--11/71 2/72--3/72
Webster-Garfield Butte	84	22	537	54	213	2/71--11/71 2/72--3/72
Whittier School Butte	130	42	323	32	120	2/71--5/71
Ramsay School Silver Bow Co	53	10	219	78	425	2/71--3/72

Table 4.1 (continued)
TOTAL SUSPENDED PARTICULATE DATA FROM HIGH VOLUME SAMPLERS FROM THE DEER LODGE VALLEY AREA
January 1971 - December 1973

Site	Geo. Mean (ug/M^3)	Geo Std. Dev. (ug/M^3)	Max 24-hr (ug/M^3)	No. Days Data	No. Days Possible*	Operational Period
City Hall Deer Lodge	50	69	237	10	59	2/71--3/71
Powell Co. Cths. Deer Lodge	49	2	201	79	305	6/71--3/72
Lahman's Powell Co.	42	5	328	287	1006	5/71--12/73
McKinley Res. Granite Co.	77	17	337	197	640	4/72--12/73

*High volume samplers were run approximately one day in three to six days to give a random sample.

Table 4.2

NUMBER OF 24-HOUR TOTAL SUSPENDED PARTICULATE VALUES EXCEEDING THE MONTANA AND FEDERAL AIR QUALITY STANDARDS FOR THE DEER LODGE VALLEY AREA

Site	Fed. Sec. 24-hr. 150 ug/m^3	Montana 24-hr. 200 ug/m^3	Fed. Prim. 24-hr. 260 ug/m^3
Anaconda Jr. High Anaconda	3	1	0
Kirkeby Anaconda	1	1	0
Bailey's Res. Deer Lodge Co.	0	0	0
Kucera's Res. Deer Lodge Co.	0	0	0
S & N Cement Deer Lodge Co.	0	0	0
Johnson Res. Deer Lodge Co.	1	1	0
Atkin's Res. Butte	1	0	0
Courthouse Butte	12	6	5
Greeley School Butte	12	3	2
Harrison Fire Sta. Butte	9	3	2
McQueen's Add. Butte	3	3	2
Old Emerson Sch. Butte	10	2	1
Silver Bow Hosp. Butte	3	2	1
Web-Gar Sch Butte	6	3	2
Whittier Sch. Butte	15	10	1
Ramsay School Silver Bow Co.	2	1	0

Table 4.2 (continued)

Site	Fed. Sec. 24-hr. 150 ug/m^3	Montana 24-hr. 200 ug/m^3	Fed. Prim. 24-hr. 260 ug/m^3
City Hall Deer Lodge Co.	2	1	0
Powell Co. Courthouse Deer Lodge Co.	5	1	0
Lahman's Powell Co.	9	4	1
McKinley Res. Granite Co.	36	13	3

TOTAL SUSPENDED PARTICULATES
January 1971 through December 1973

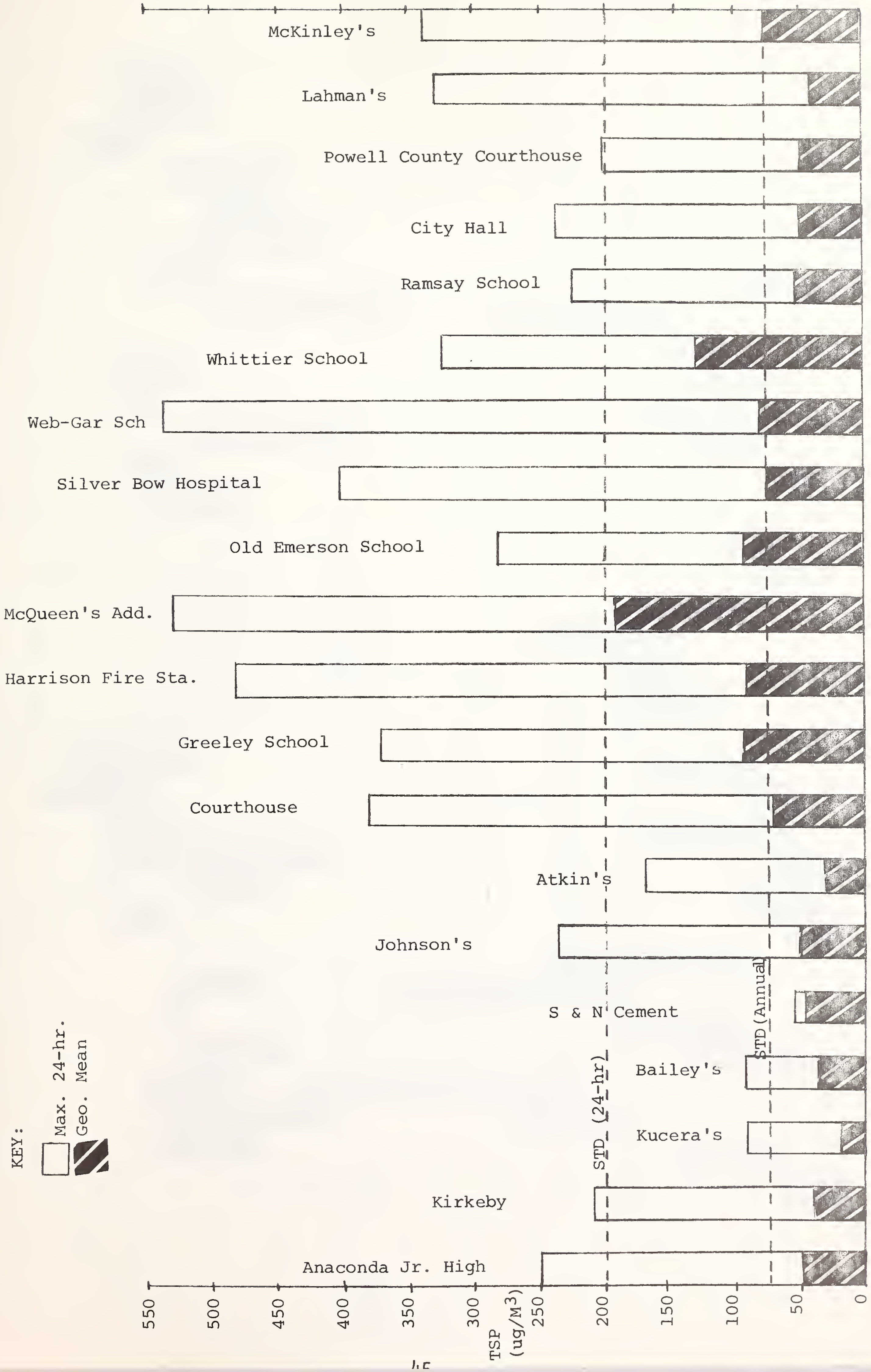
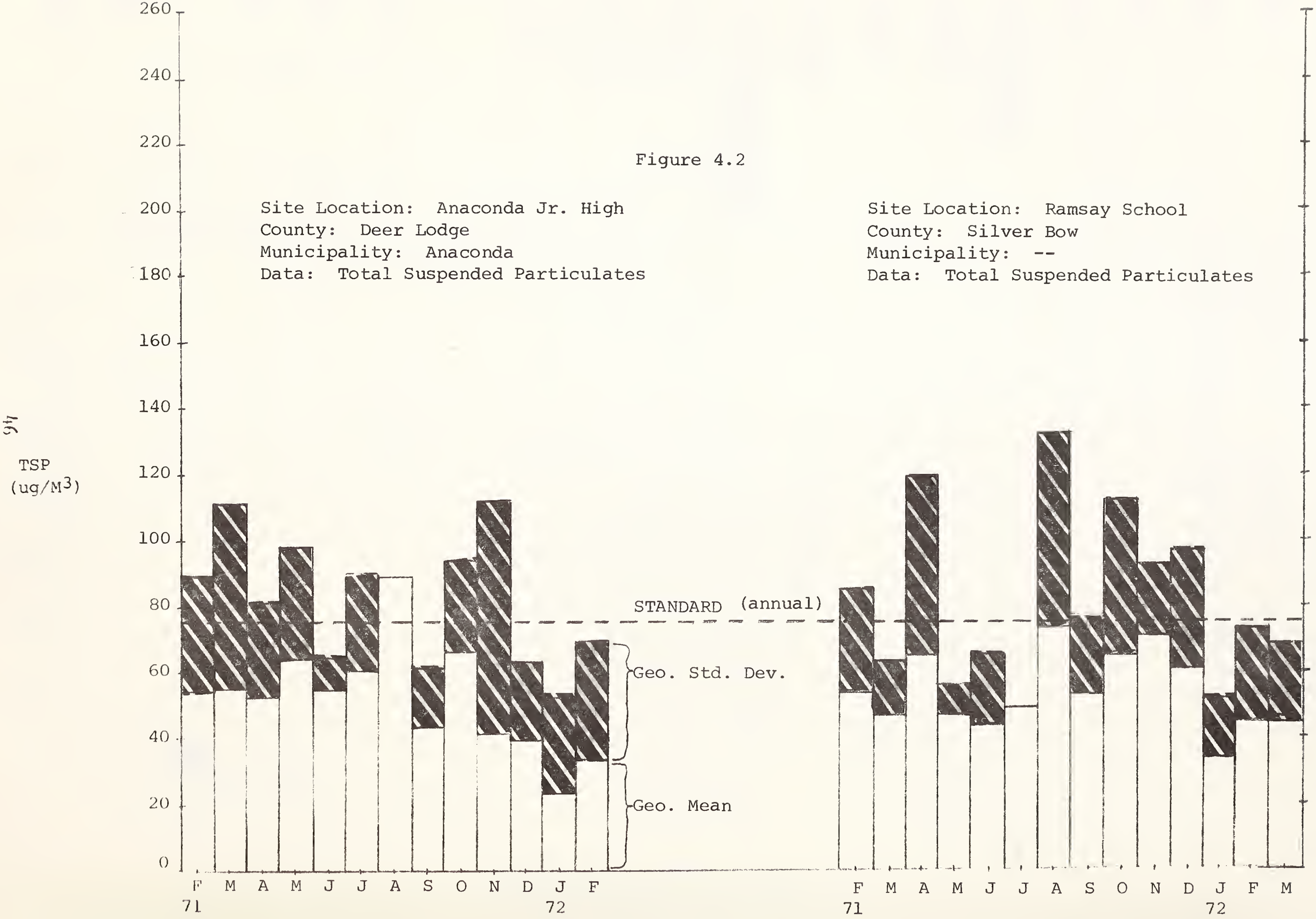


Figure 4.2


Site Location: Anaconda Jr. High
County: Deer Lodge
Municipality: Anaconda
Data: Total Suspended Particulates
Site Location: Ramsay School
County: Silver Bow
Municipality: --
Data: Total Suspended Particulates
TSP
(ug/M^3)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
STANDARD (annual)
Geo. Std. Dev.
Geo. Mean
F M A M J J A S O N D J F
71
72
F M A M J J A S O N D J F M
71
72

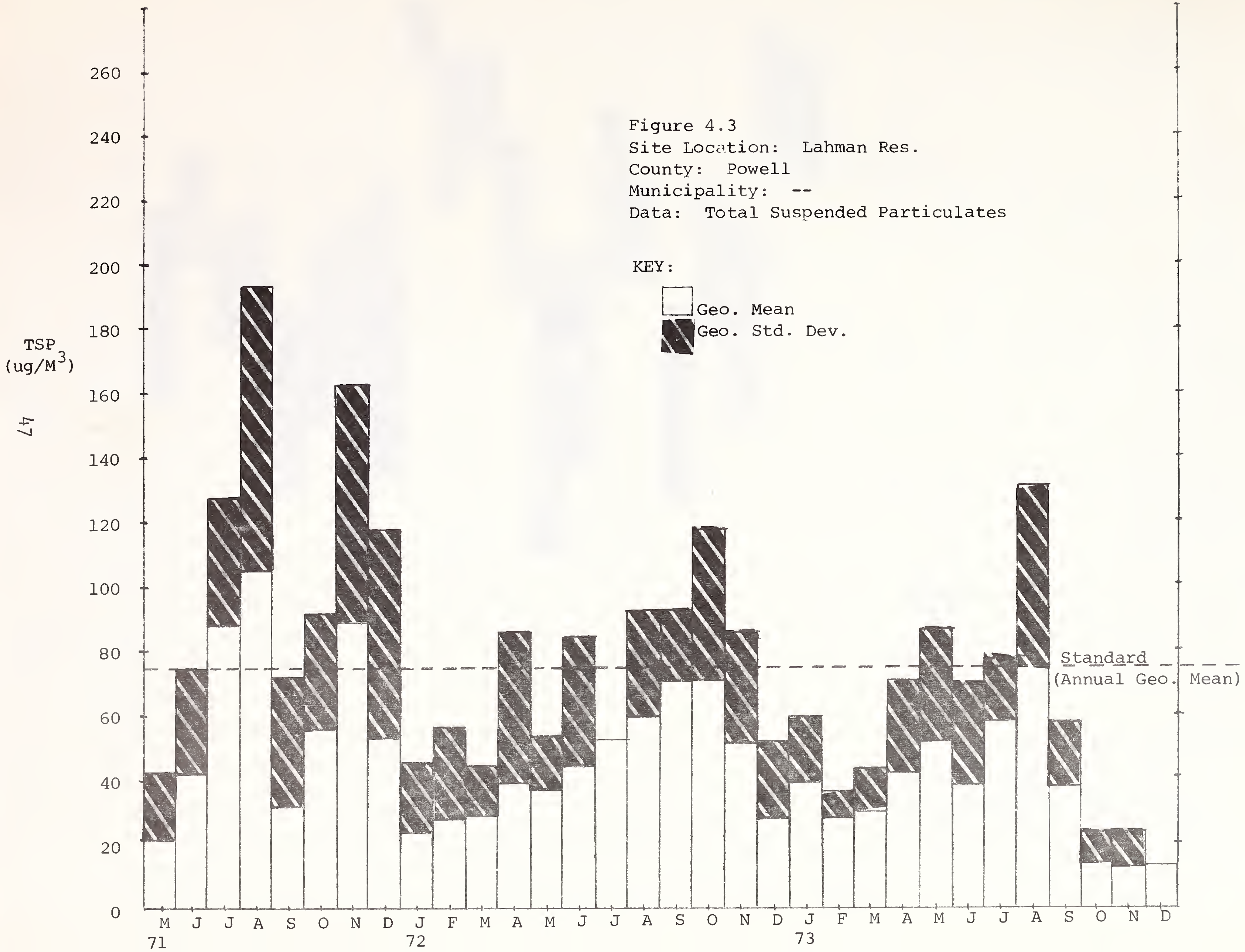


Figure 4.3
Site Location: Lahman Res.
County: Powell
Municipality: --
Data: Total Suspended Particulates

Figure 4.4

Site Location: McKinley Res.
County: Granite
Municipality: --
Data: Total Suspended Particulates

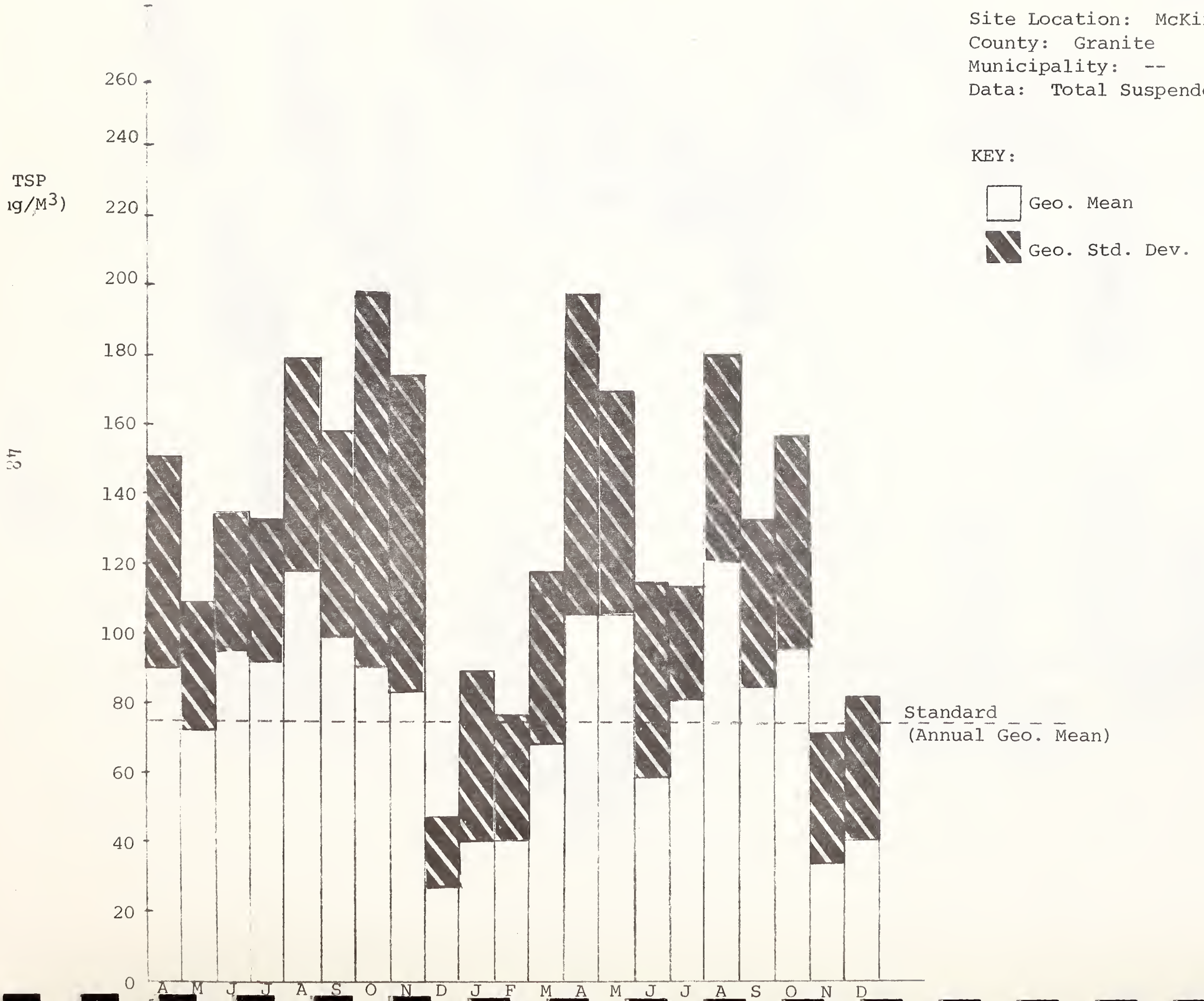


Table 4.3
Comparison of Past Levels of Atmospheric Pollutants(22)(23)
(Values are arith. averages in micrograms per cubic meter)

City	Year	No. of Samples	Total Sus. Particulates	Arsenic	Lead
Anaconda	1961-62	123	89	0.45	0.54
	1971-72	194	52	0.27	0.41
Butte	1961-62	123	125	0.07	0.41
	1971-72	48	109	0.07	0.82
Garrison	1965-66	93	109	0.10	0.09
	1971-72	287	54	0.12*	0.35*
Deer Lodge	1965-66	93	70	0.10	0.09
	1971-72	89	54	0.08+	0.34+

*Average is for 79 samples
+Average is for 10 samples

Table 4.4

Deer Lodge Valley Study
Trace Element Analysis
(Aver. value in ug/m3/no. of samples)

Site Location	Oper. Period	Arsenic	Lead	Cadmium	Zinc
Kirkeby Res. Anaconda	4/72--11/72	0.17/69	0.35/73	0.025/75	0.64/75
Anac. Jr. Hi. Sch. Anaconda	2/71--3/72	0.34/110	0.46/115	0.026/114	0.95/115
Bailey Res. Deer Lodge County	10/71--11/71	0.51/7	0.36/7	0.04/7	1.07/7
Kucera Res. Deer Lodge County	12/72--5/73	0.19/44	0.15/49	0.02/49	0.33/49
Johnson Res. Deer Lodge County	5/71--11/71	0.43/41	0.52/38	0.01/41	3.44/41
Courthouse Butte	2/71--3/72	0.13/84	0.51/82	0.04/83	0.35/83
Emerson School Butte	1/71--7/71	0.38/40	0.58/40	0.04/40	0.35/40
Greeley School Butte	2/71--3/72	0.19/76	0.46/72	0.02/76	0.30/74
Harrison St. Fire station--Butte	7/71--3/72	0.07/48	0.82/48	0.02/48	0.29/48
McQueen's Addition Butte	3/72--4/72	0.14/12	0.25/12	0.02/12	0.94/12
Silver Bow Gen. Hosp.--Butte	7/71--3/72	0.15/46	0.42/43	0.03/46	0.35/46
Webster-Gar. Sch. Butte	2/71--3/72	0.15/83	0.79/81	0.02/82	0.35/82
Whittier Sch. Butte	2/71--5/71	0.32/32	0.36/32	0.02/32	0.44/32
Ramsay School Silver Bow County	2/71--3/72	0.24/70	0.28/70	0.07/71	0.73/72
City Hall Deer Lodge	2/71--3/71	0.08/10	0.34/9	0.02/10	0.20/10
Powell Co. Courthouse-Powell Co.	6/71--3/72	0.12/79	0.35/78	0.02/79	0.28/79

Table 4.5

SEASONAL AVERAGES OF SETTLEABLE PARTICULATES
(Values in Tons/Sq. mile)

Site Location	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Max.	Min.	Dates of Operation
Anac. Jr. High Deer Lodge Co.	90.0*	6.1*	41.3**	7.6**	90.0	3.4	Jul 71-Mar 72
Hwy 48 Jct. Deer Lodge Co.	3.8*	--	--	--	3.8	3.8	Mar. 73
Lost Creek Deer Lodge Co.	0.1*	--	--	--	0.1	0.1	Mar. 73
Johnson Ranch Deer Lodge Co.	--	--	28.9**	12.2	53.4	4.4	Oct. 71-Feb. 72
Harrison St. Fire Sta. Silver Bow Co.	35.0*	11.8**	24.0	13.1	35.0	7.7	Jul.71-Mar.72
Web.-Gar. Sch. Silver Bow Co.	21.0	8.6**	20.8	11.6	35.4	6.7	Feb 71-Mar 72
Silver Bow Gen. Hosp. Silver Bow Co.	--	17.5**	11.3	7.5	23.6	0.2	Jul 71-Feb 72
Whittier Sch. Silver Bow Co.	38.4**	--	9.1*	21.0*	42.9	9.1	Feb 71-Nov 72
Greeley Sch. Silver Bow Co.	24.6	11.0	18.4	12.7	43.7	0.5	Feb 71-Mar 72
Courthouse Silver Bow Co.	41.4	12.5	41.0**	13.1	64.0	7.8	Feb 71-Mar 72
Old Emer. Sch. Silver Bow Co.	24.8**	9.6*	--	--	40.0	9.6	Apr 71-Jun 71
Ramsay Sch. Silver Bow Co.	20.1	--	38.0**	6.8	69.0	3.4	Feb 71-Mar 72
Courthouse Powell Co.	37.5	--	15.9	30.2	111.5	2.1	Feb 71-Mar 72
Berg Motel Granite Co.	41.6	53.2	61.0	116.0	237.5	24.0	Feb 72-Dec 73
E. of Church Granite Co.	99.4	118.1	14.6	16.0	295.0	2.0	Feb 72-Nov 73
Whitberg Ranch Granite Co.	22.6	18.6	8.3	2.3	78.8	0.0	Feb.72-Dec 73
Whitberg H. Pond Granite Co.	166.4	94.7	6.2	4.1	380.0	1.9	Feb 72-Dec 73

Table 4.5 (continued)

Site Location	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Max.	Min.	Dates of Operation
McKinley Res. Granite Co.	--	--	--	3.7*	3.7	3.7	Dec. 73
Ousley Res. Granite Co.	129.5	155.7	134.0	203.6**	353.6	108.6	Feb.73 - Dec.73
Flint Valley Off. Granite Co.	11.8**	10.6**	13.4	1.1*	16.8	1.1	Apr 73-Dec 73
Pburg Airport Granite Co.	179.0**	184.0	198.0	73.2*	215.0	73.2	Apr 73-Dec 73

* Only one sample
**Only two samples

Figure 4.5

SETTLEABLE PARTICULATES
(Dustfall)

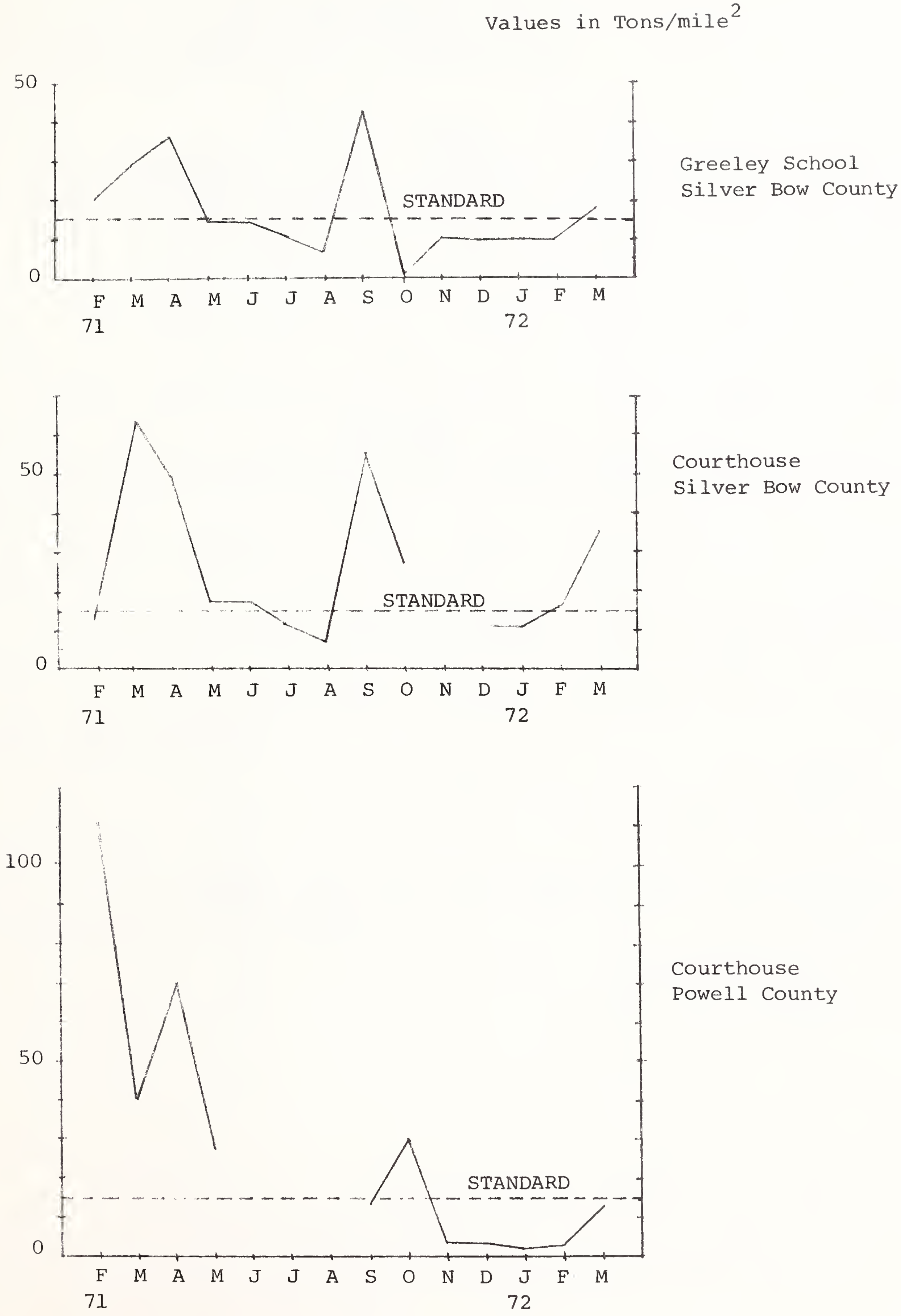
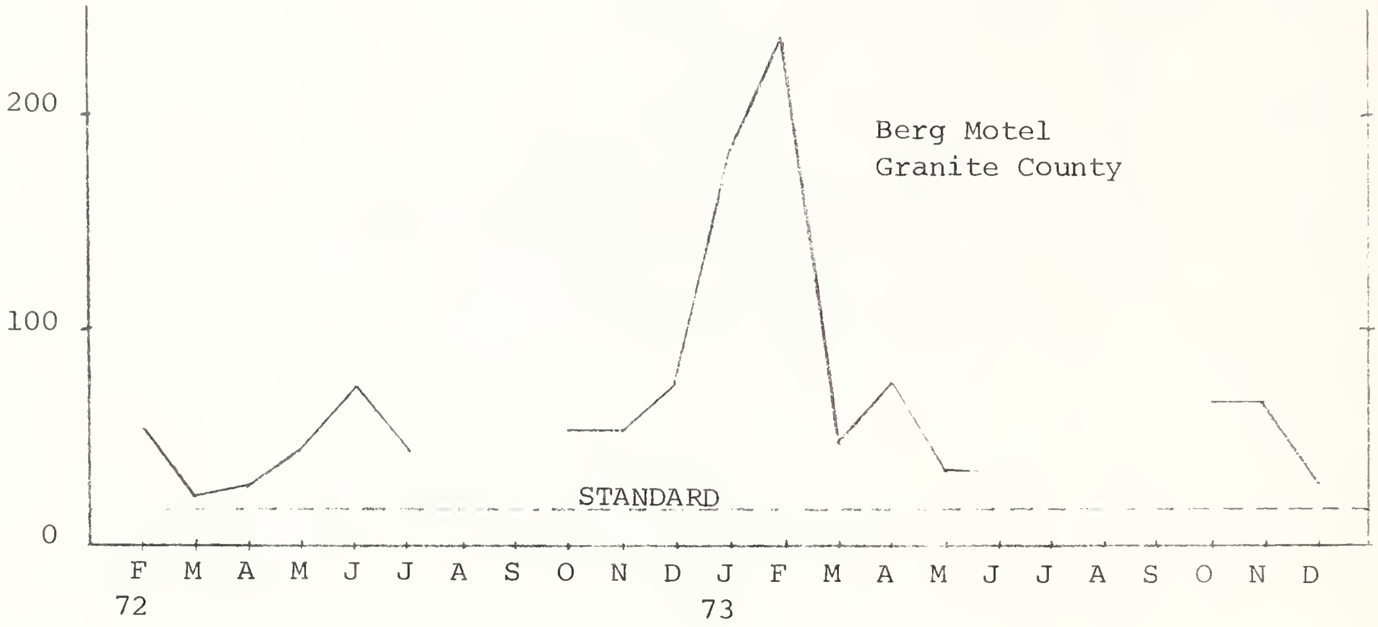


Figure 4.6

Settleable Particulates
(Dustfall)

Values in Tons/mile^2



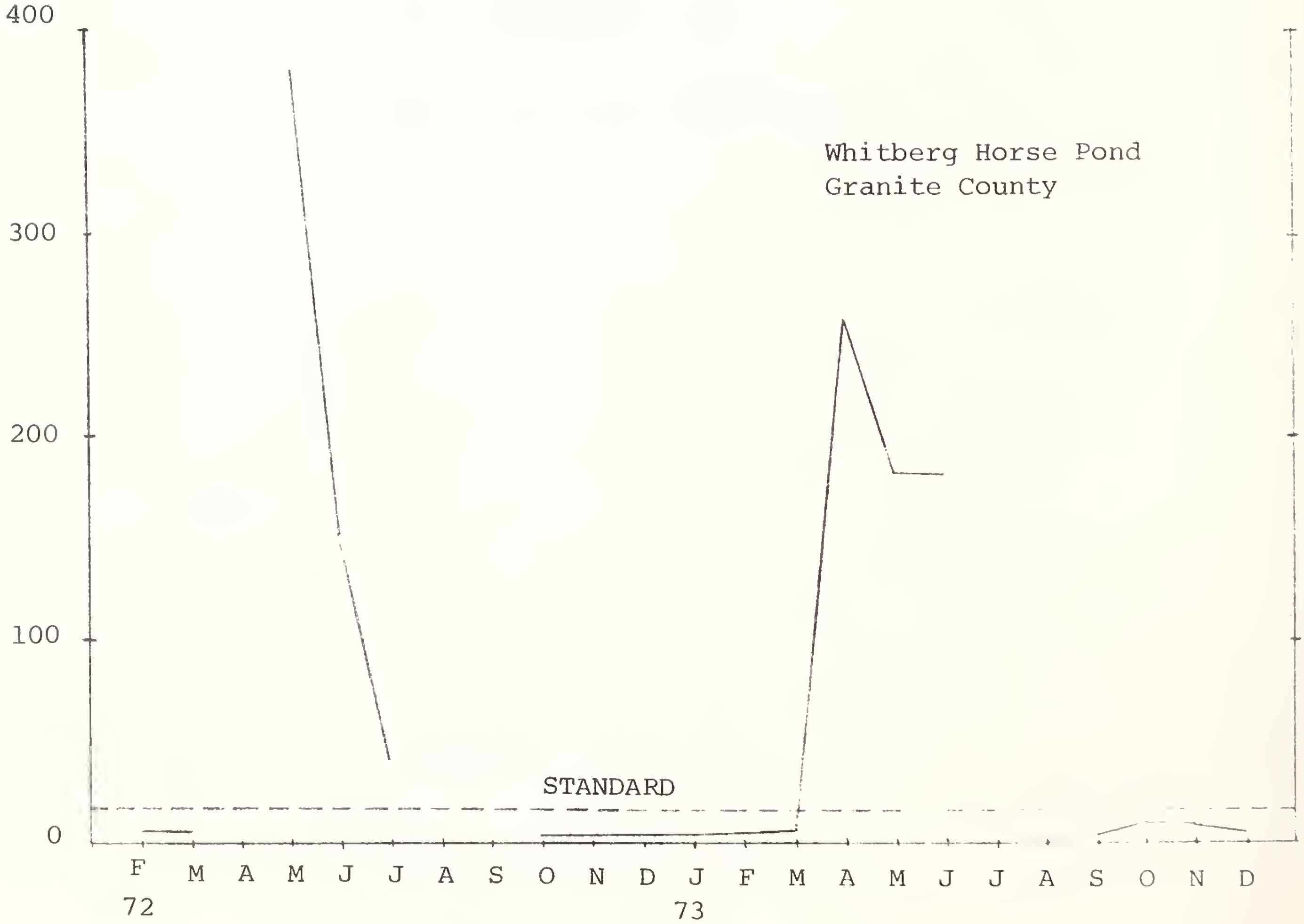


Table 4.6

SULFUR DIOXIDE DATA*
FROM CONTINUOUS SAMPLERS
FROM THE DEER LODGE VALLEY AREA
OCTOBER 1971 - DECEMBER 1973

Site	Arith. Aver.	Max. 1-hr	Max. 3-hr	Max. 24-hr	Total Readings Possible**	Number Readings Taken	Total ppm SO_2	Operational Period
Antelope Cr. Deer Lodge Co.	0.01	0.42	0.37	0.07	5988	4544	22.98	2/73-10/73
Bailey Res. Deer Lodge Co.	0.02	0.45	0.41	0.29	1140	1017	17.53	10/71-11/71
Kucera Res. Deer Lodge Co.	0.01	0.45	0.31	0.09	4744	3432	35.43	11/72-6/73
Poor Farm Deer Lodge Co.	0.01	0.70	0.45	0.35	10,968	7957	88.47	11/71-1/73
Warm Springs Deer Lodge Co.	0.00	0.00	0.00	0.00	1548	989	0.0	12/71-2/72
Willow Glen Deer Lodge Co.	0.01	0.50	0.30	0.11	7080	5329	41.18	3/73-12/73
Cortright Deer Lodge Co.	0.01	0.35	0.18	0.04	3500	2490	7.93	6/72-11/72

*Values in ppm

**Total readings possible does not take into account hours not operated due to calibrations and other maintenance.

Table 4.7

NUMBER OF VALUES EXCEEDING THE MONTANA AND FREDERAL AIR QUALITY STANDARDS* OF SULFUR DIOXIDE FOR THE DEER LODGE VALLEY AREA

Site	0.25 (1 hr)	0.50 (3 hr)	0.10 (24 hr)	0.14 (24 hr)	From Main Stack Distance Miles	Direction
Antelope Creek Deer Lodge Co.	9	0	0	0	6.7	NNE
Bailey Res. Deer Lodge Co.	17	0	1	1	4.6	SE
Kucera Res. Deer Lodge Co.	26	0	0	0	1.6	SE
Poor Farm Deer Lodge Co.	56	0	5	2	5.1	NNE
Warm Springs Deer Lodge Co.	0	0	0	0	7.4	NE
Willow Glen Deer Lodge Co.	14	0	1	0	3.1	ESE
Cortright's Deer Lodge Co.	5	0	0	0	3.7	E

*Values exceeding levels above are not necessarily violations of the Montana and Federal air quality standards - See Appendix IV

Figure 4.7

SULFUR DIOXIDE DATA
(Continuous Analyzer)

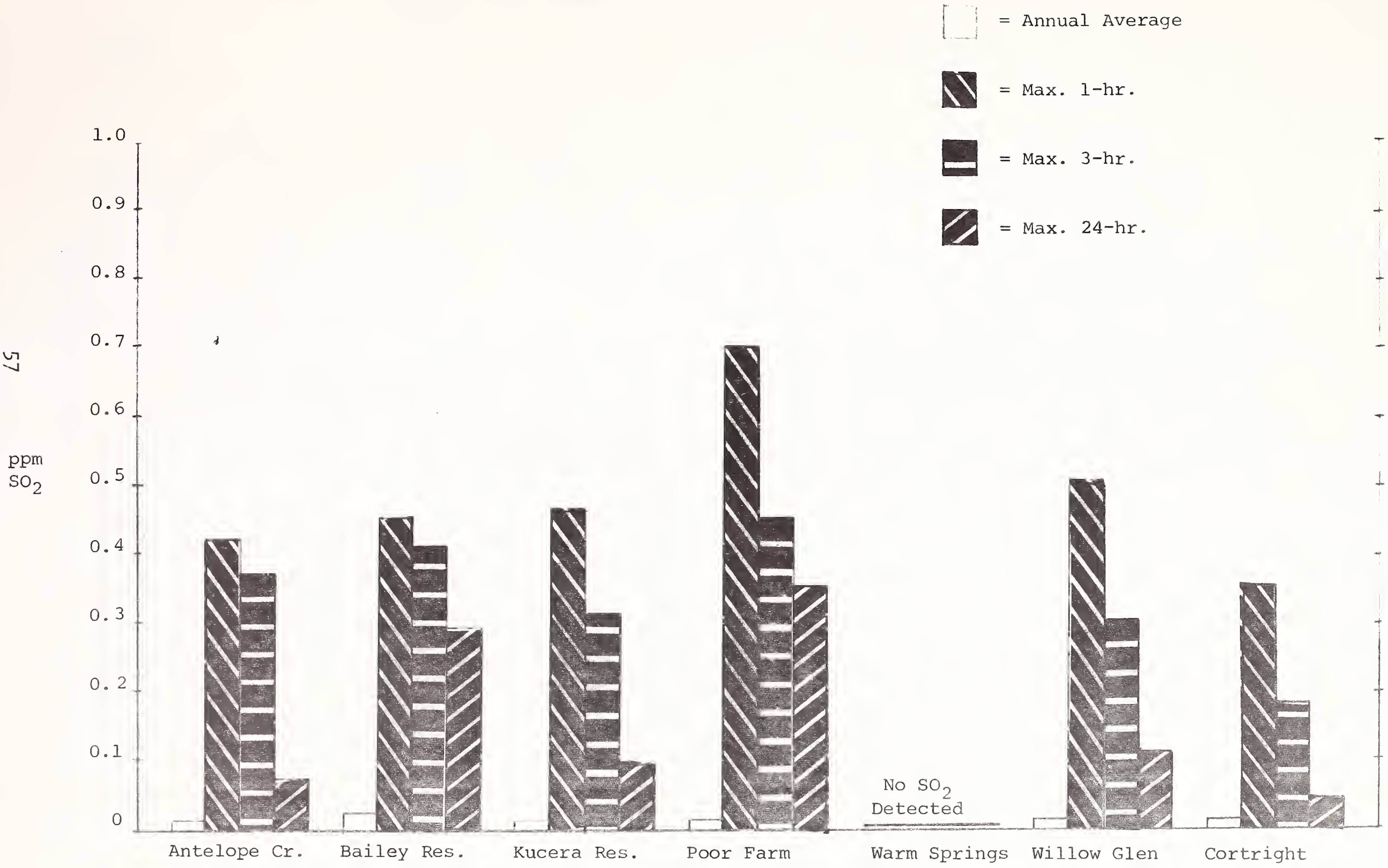


Figure 4.8
SULFATION RATE
(Lead Plate Method)

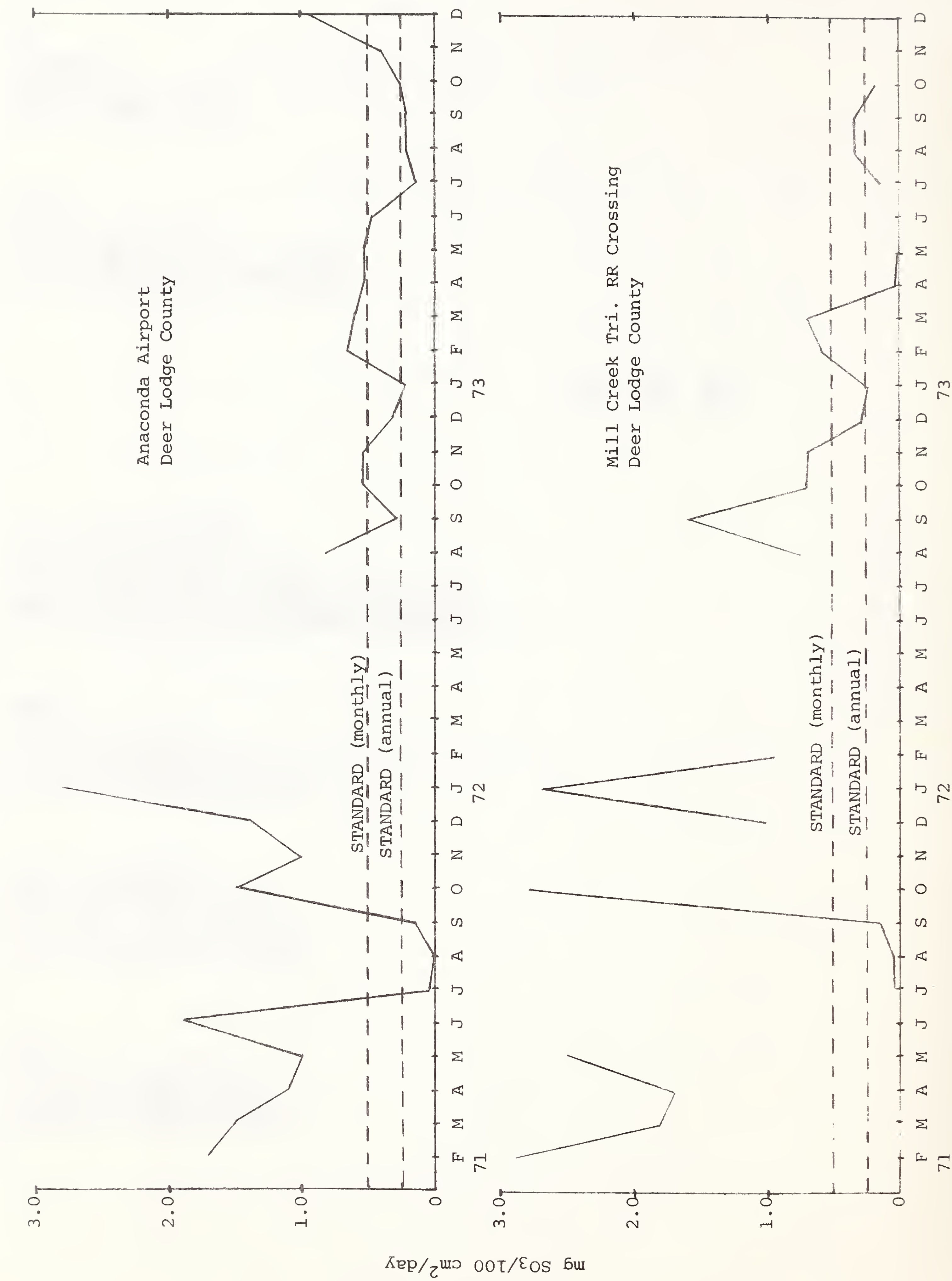


Figure 4.9
SULFATION RATE
(Lead Plate Method)

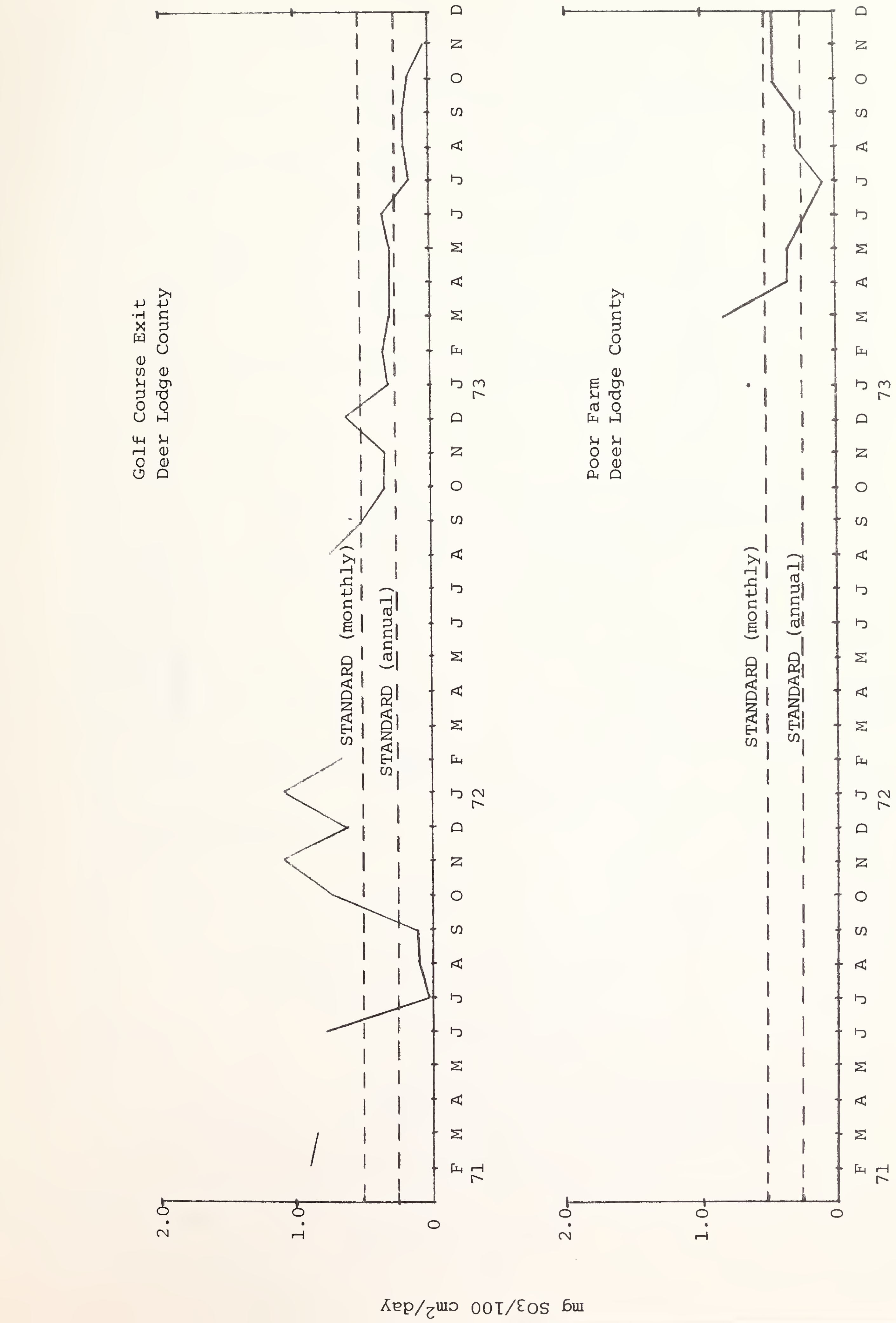


Figure 4.10
SULFATION RATE
(Lead Plate Method)

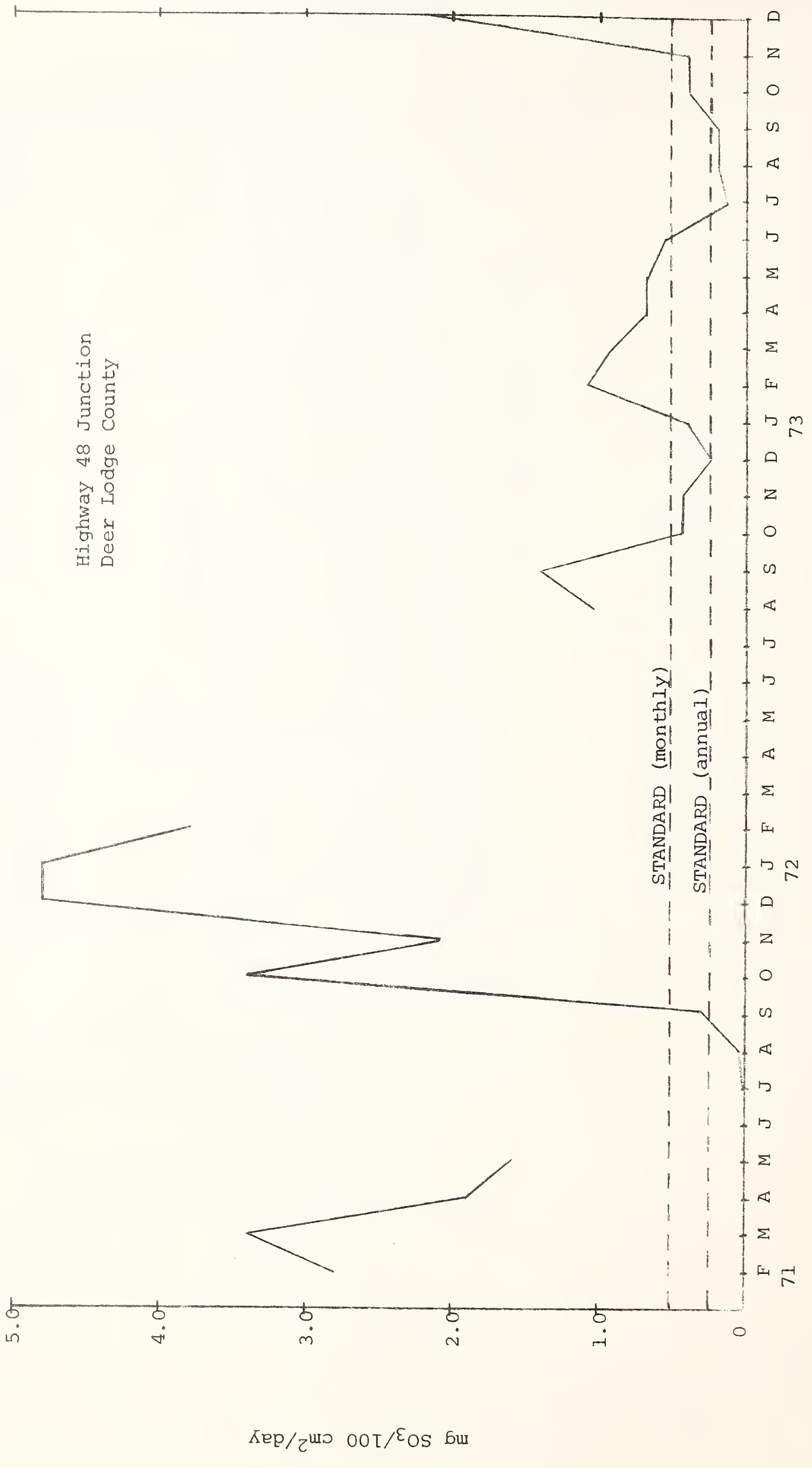


Figure 4.11
SULFATION RATE
(Lead Plate Method)

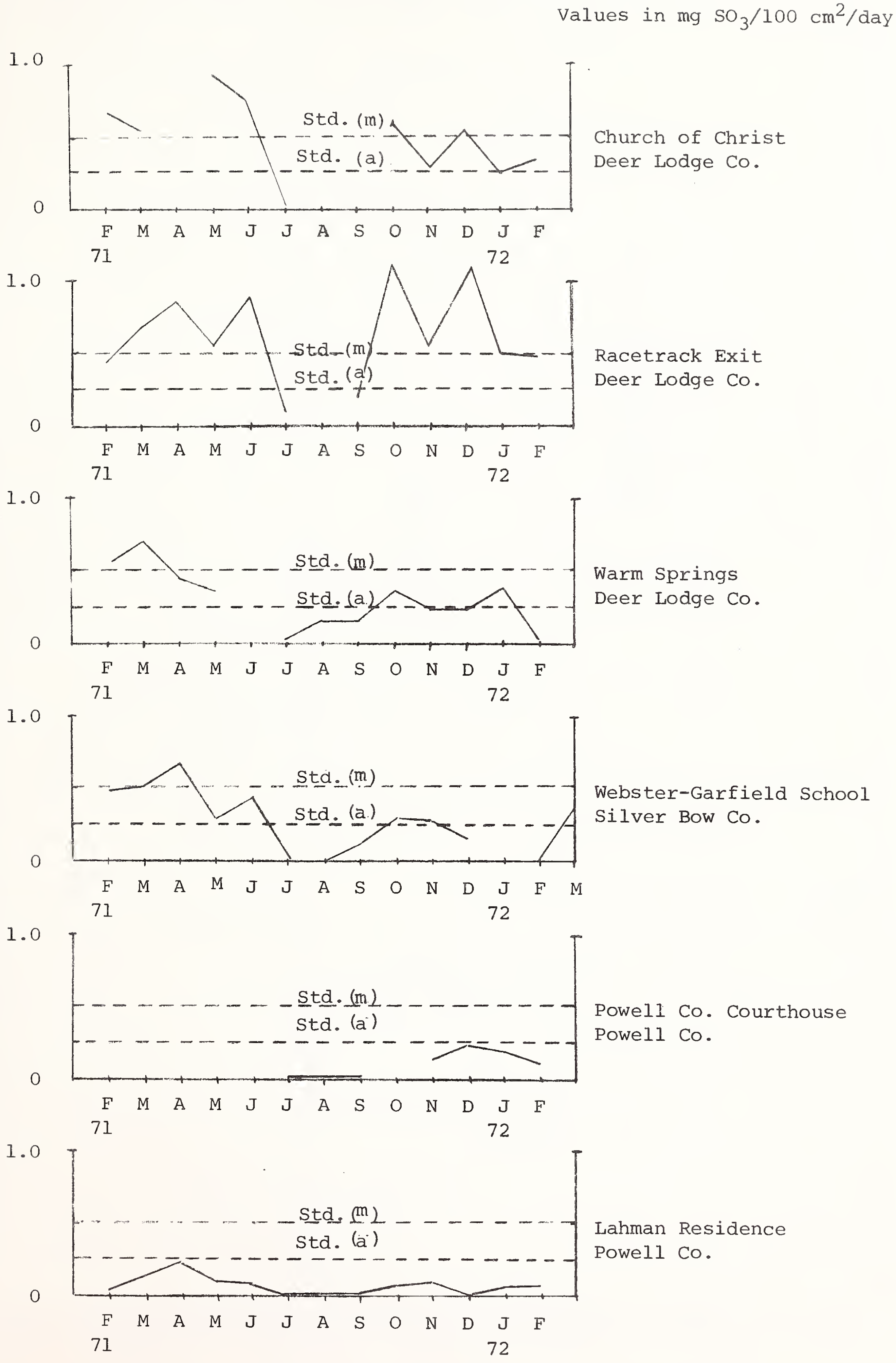


Figure 4.12
Ca FORMATE (F⁻) PAPERS

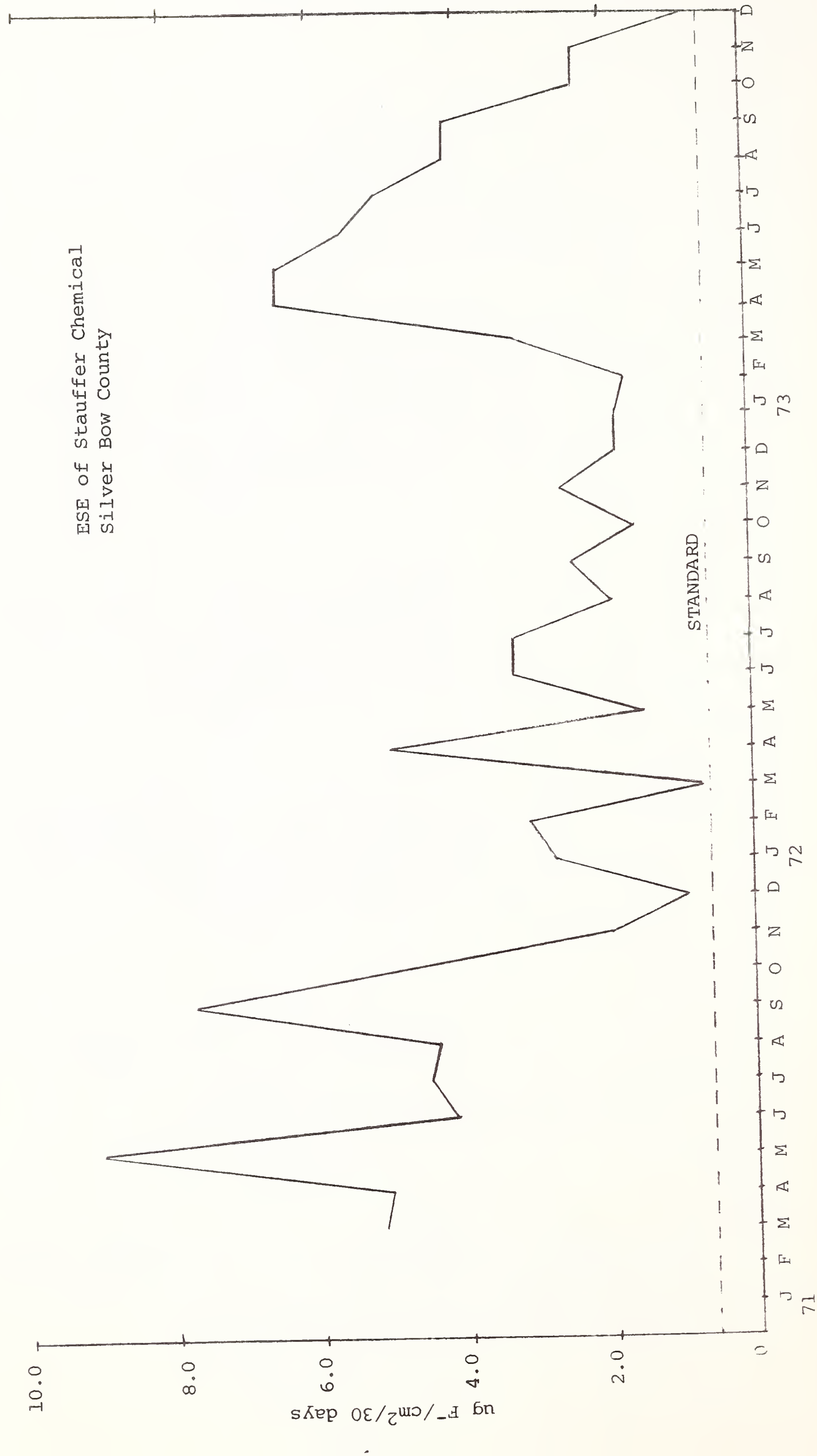


Figure 4.13
Ca FORMATE (F⁻) PAPERS

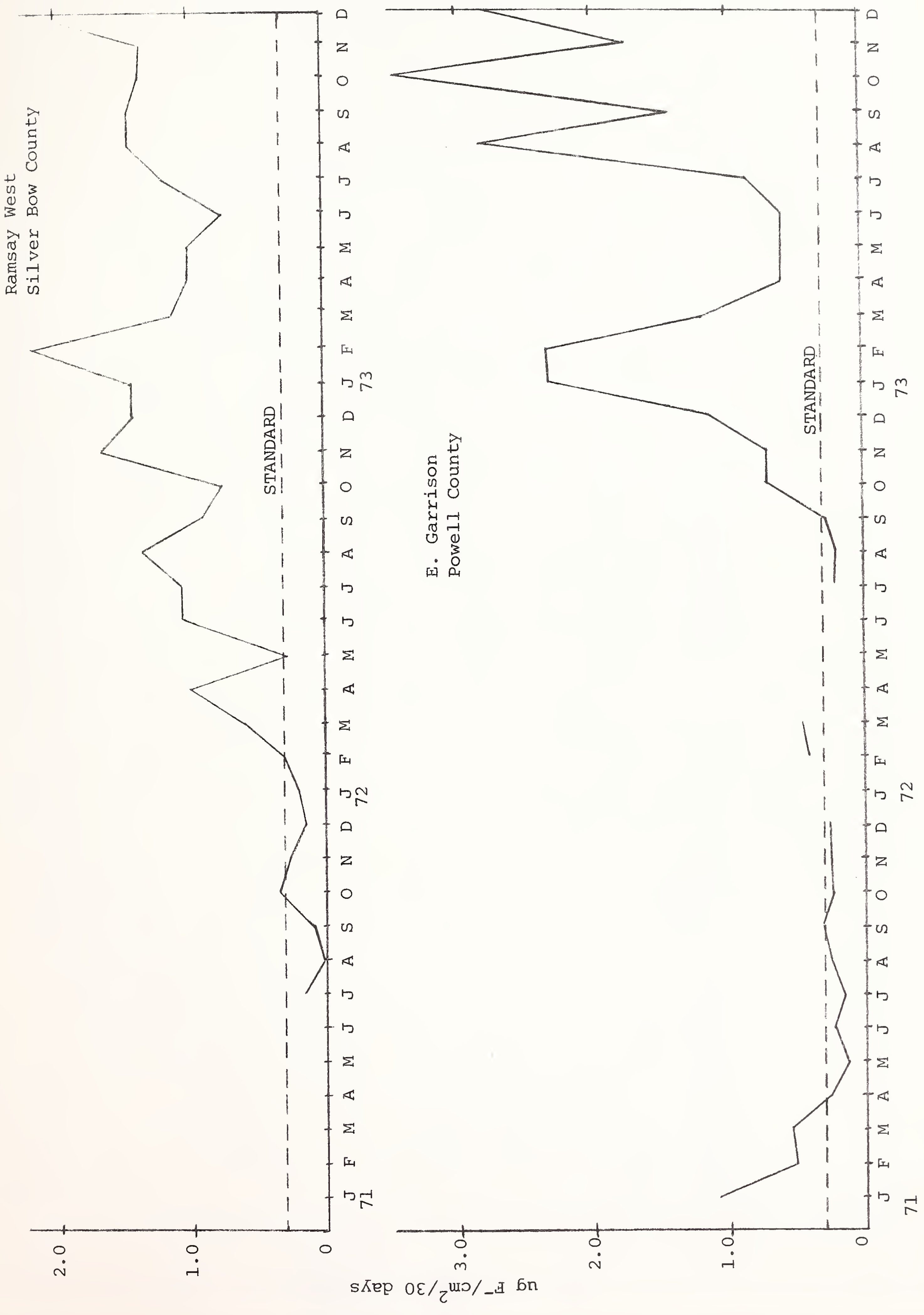


Figure 4.14
Ca Formate (F^-) Papers

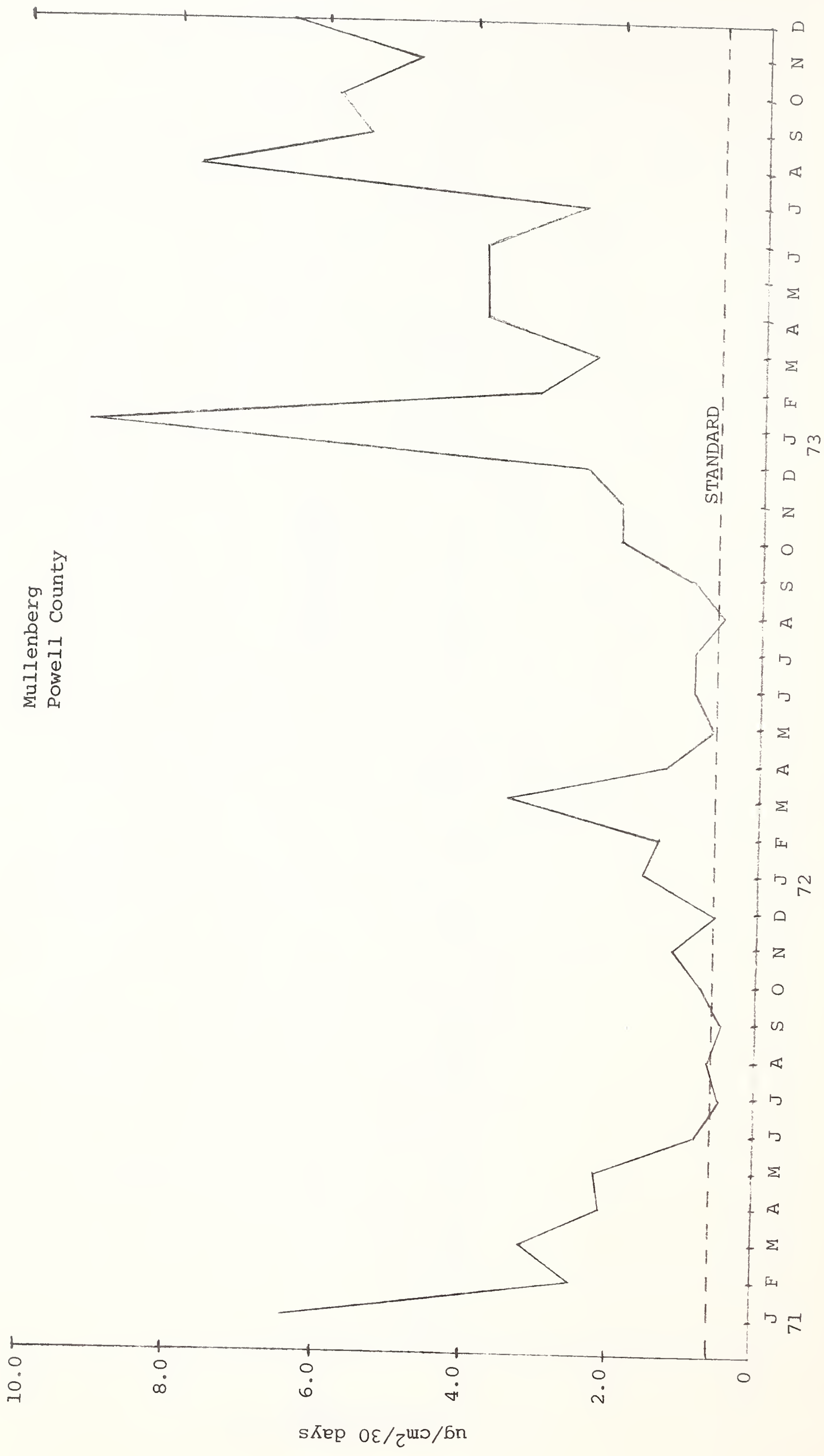


Figure 4.15

Ca Formate (F^-) Papers

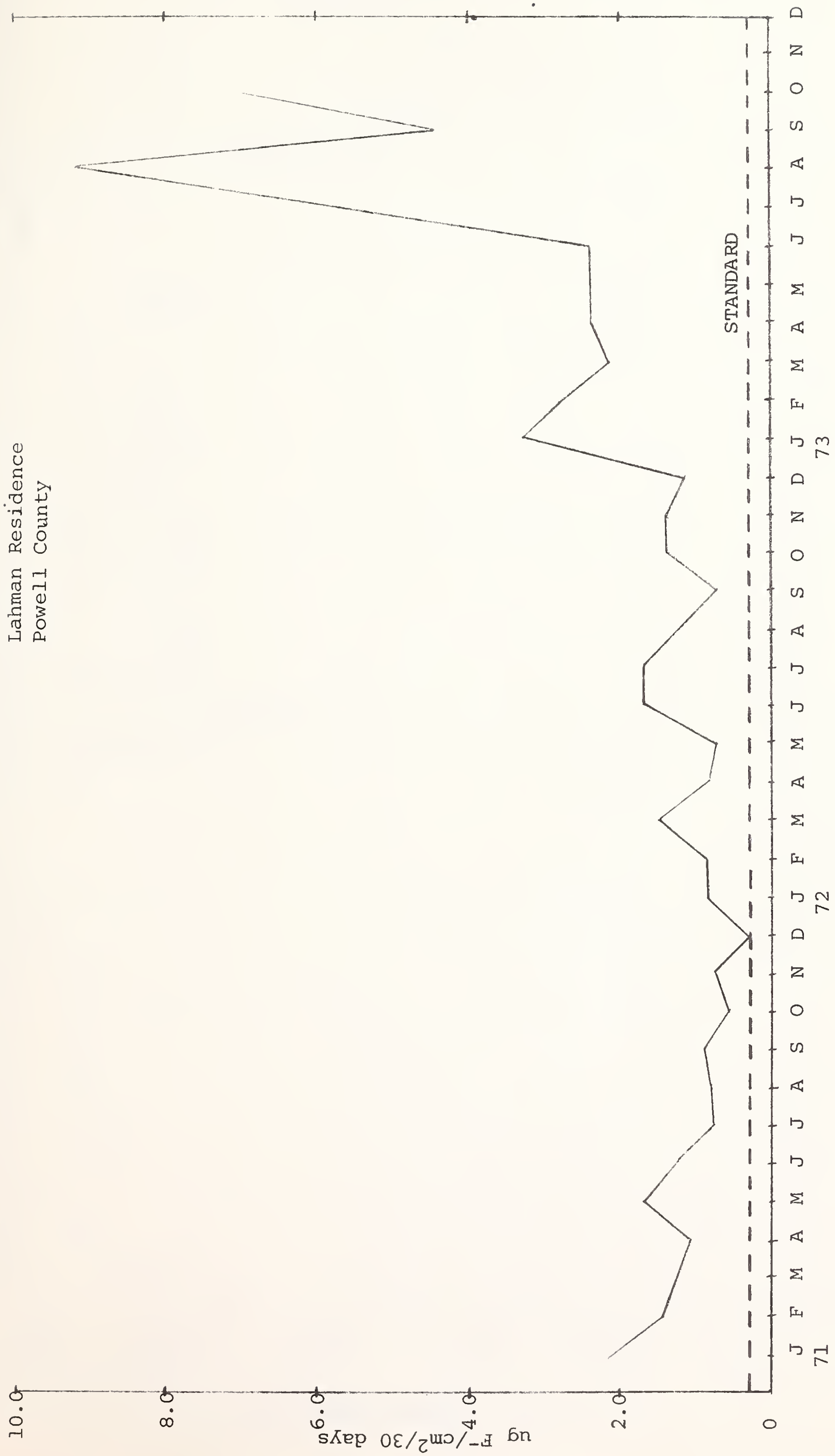
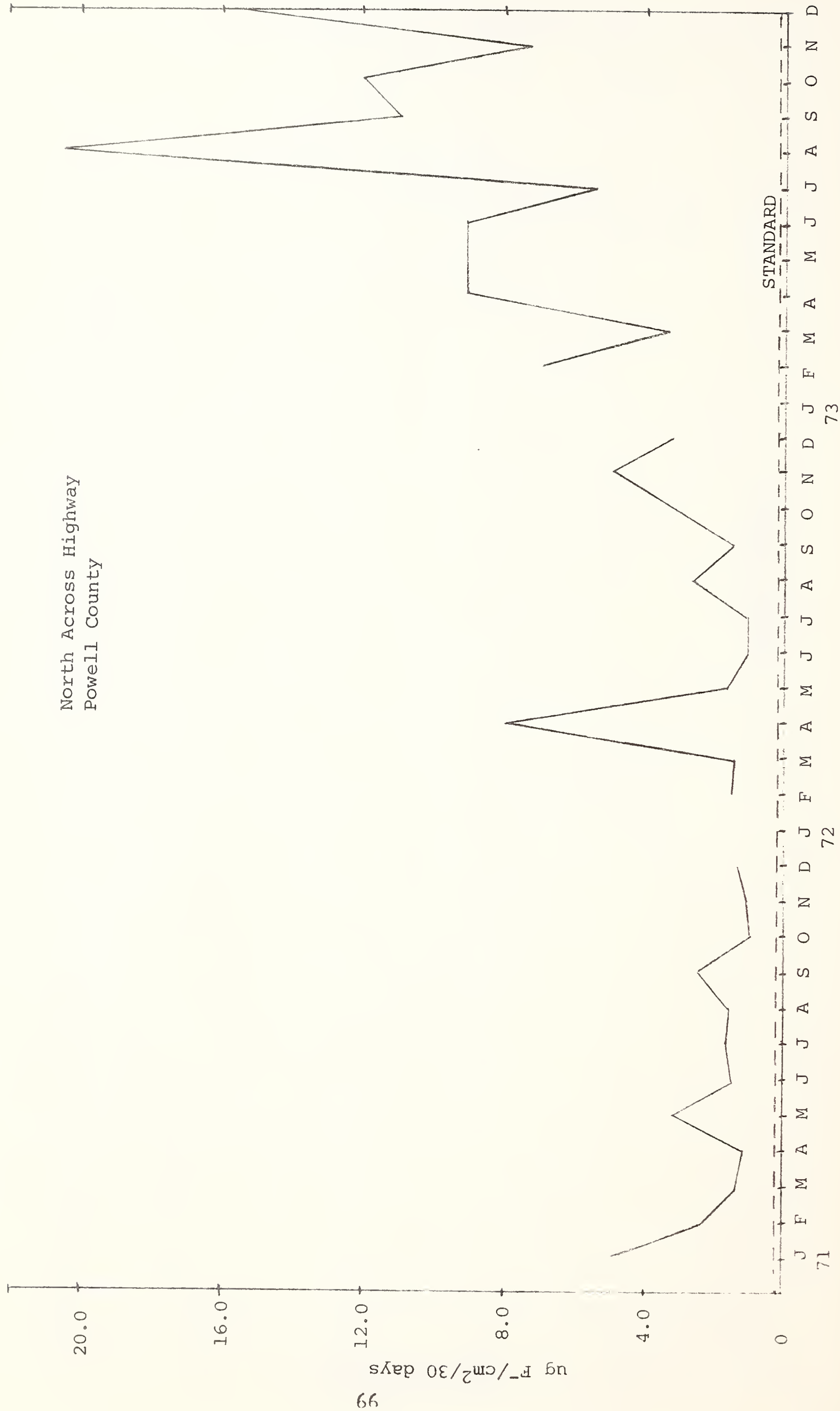
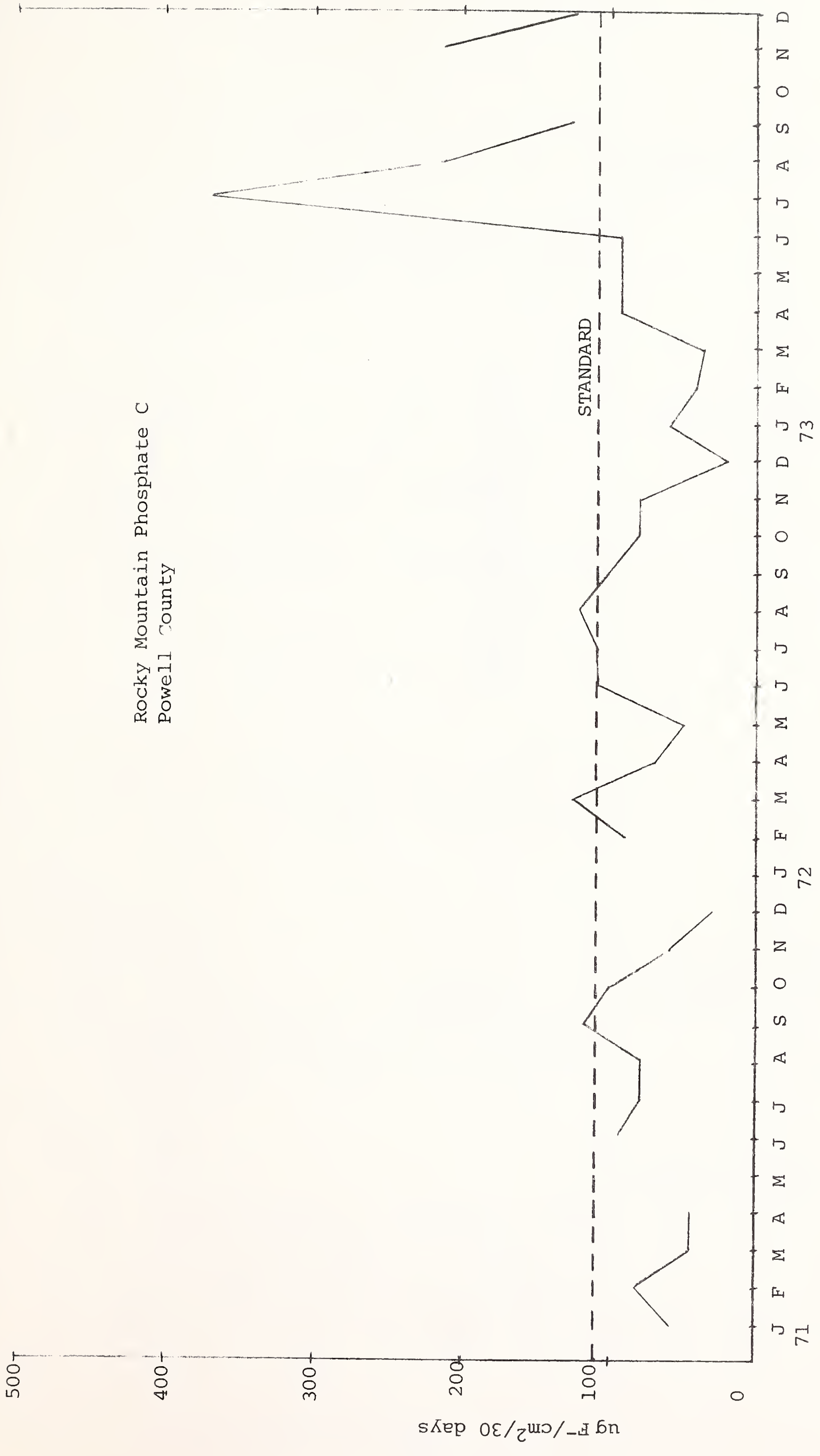


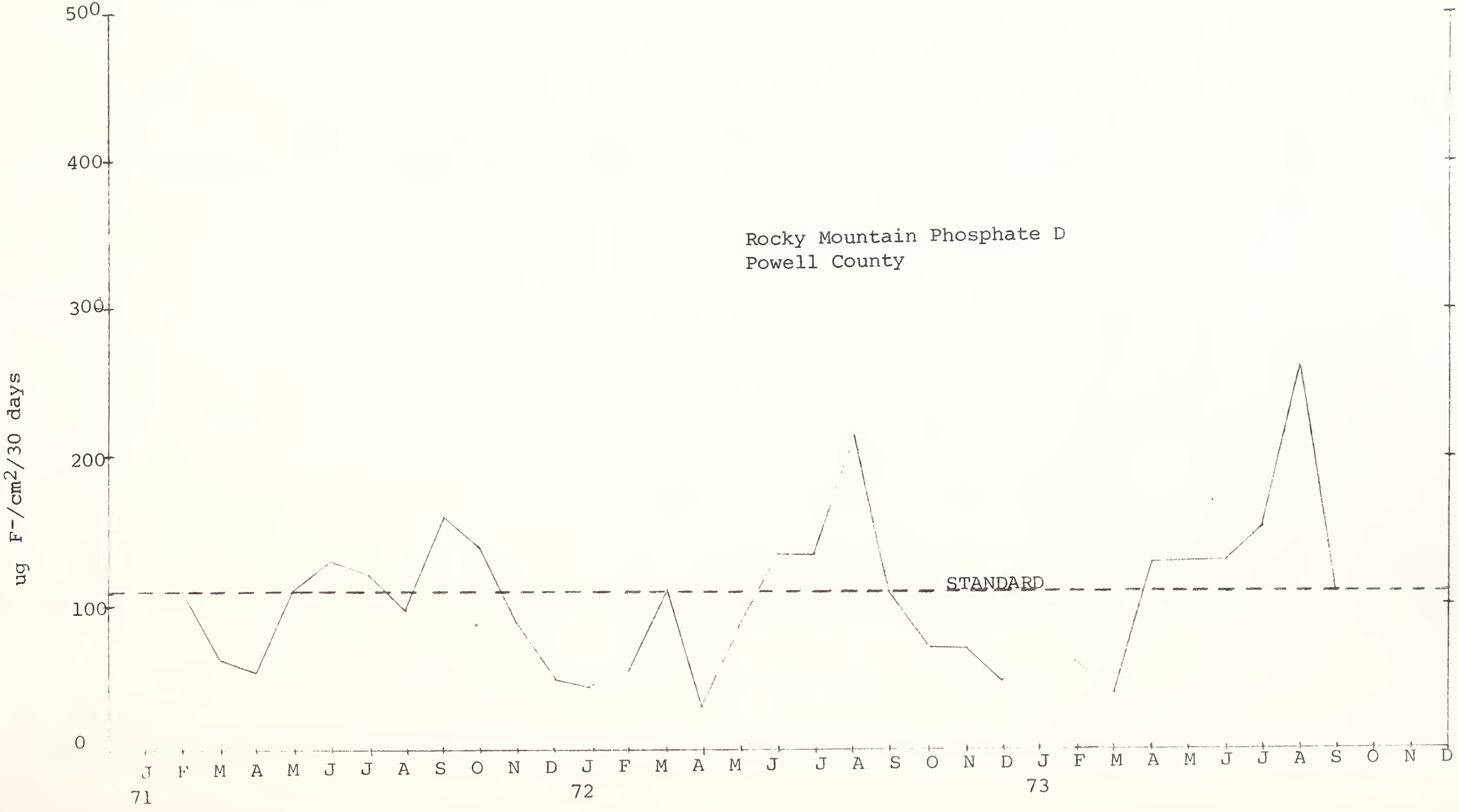
Figure 4.16

Ca Formate (F^-) Papers

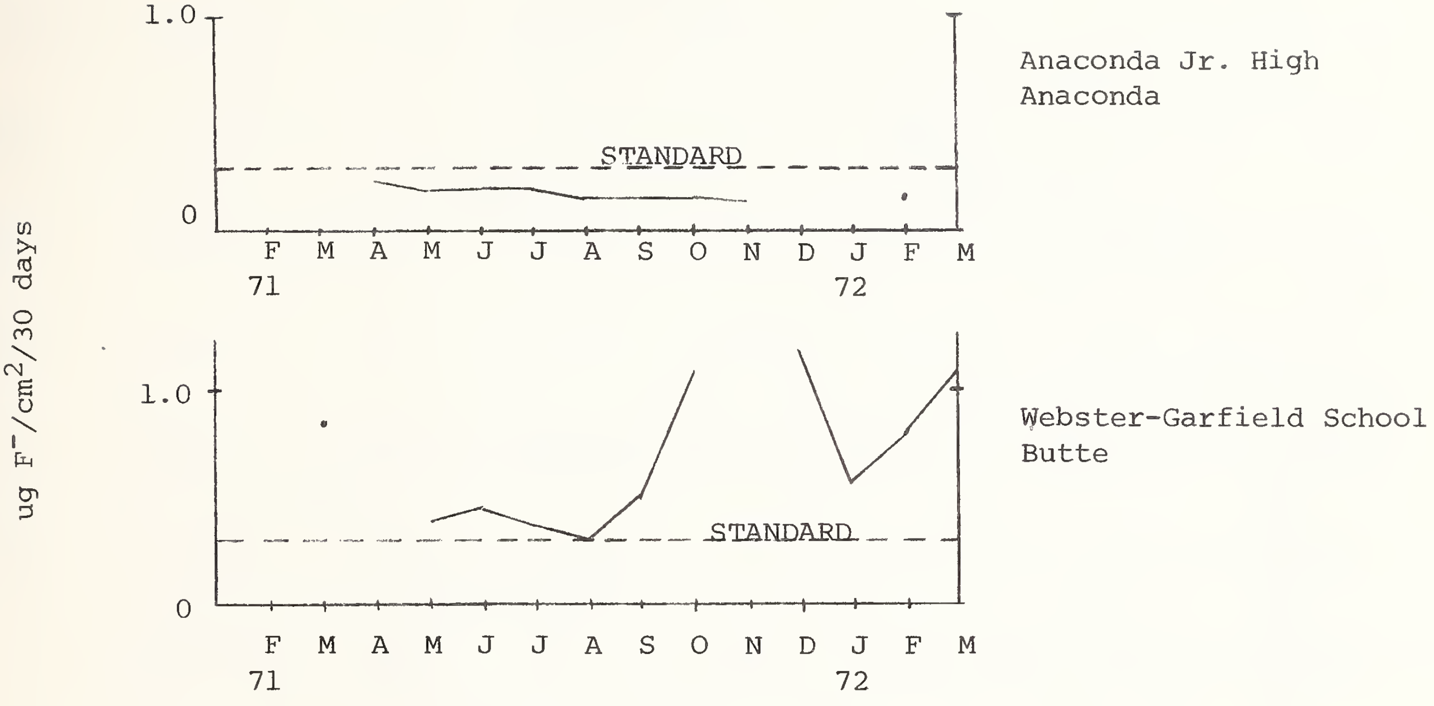


Ca Formate (F⁻) Papers




Rocky Mountain Phosphate D
Powell County

Na Formate (F^-) Plates



Ca Formate (F^-) Papers

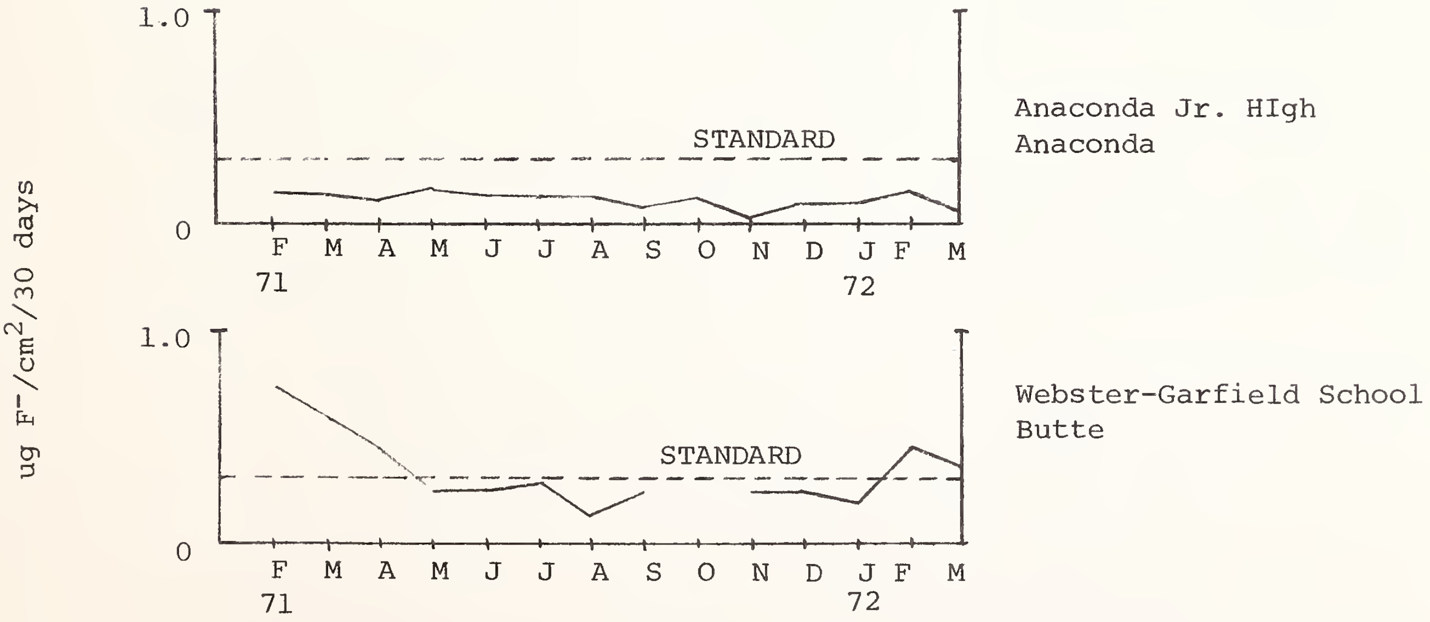


Figure 4.20
Na FORMATE (F⁻) PLATES

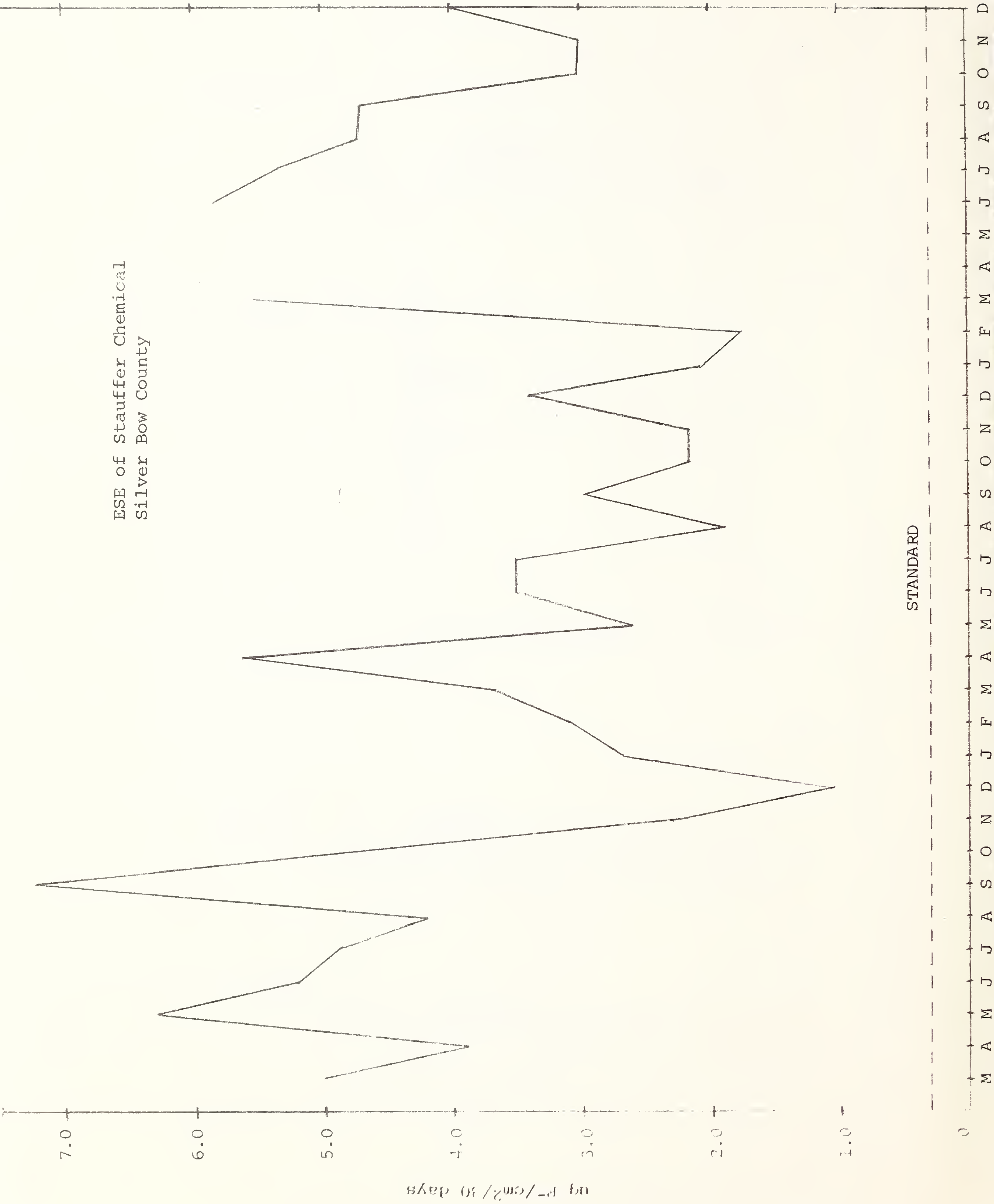


Table 4.8

SEASONAL AVERAGES OF FLUORIDE IN VEGETATION AROUND ROCKY MOUNTAIN PHOSPHATES, INC.

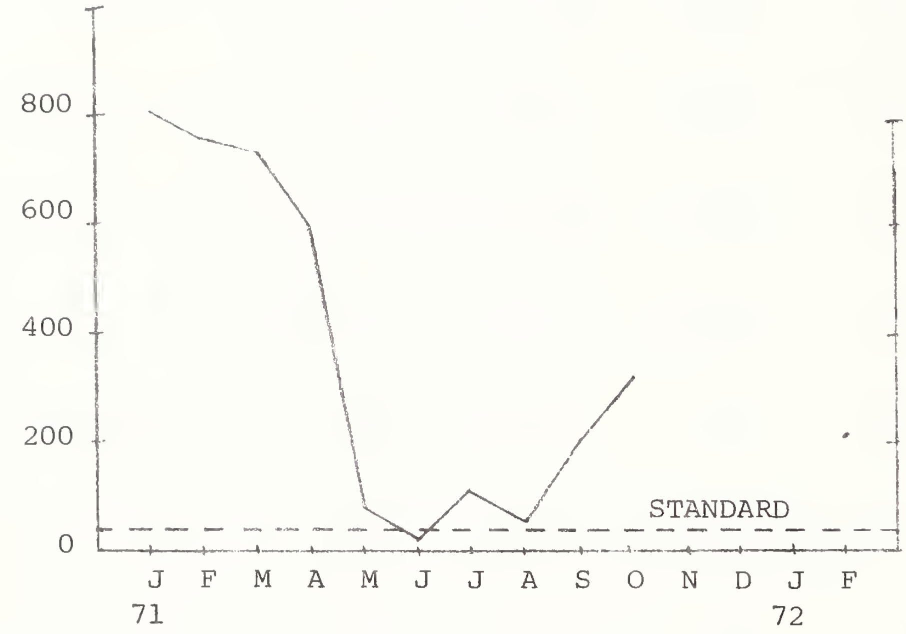
Site Location	Mar-May	Jun-Aug	Sep-Nov	Dec-Feb	Max.	Min.	Dates of Operation
N. Station Powell Co.	15.4*	1.2	12.2	11.6	67.2	0.0	Mar. 69 - Oct. 71
Mullenberg Powell Co.	359.0	17.1	100.4	394.3	1100.0	0.0	June 69 - Feb. 72
E. Garrison Powell Co.	36.4	8.7	44.2	68.8	96.0	0.0	Mar. 69 - Oct. 71
N. Ac. Hwy Powell Co.	328.3	40.8	374.2	852.4	1500.0	4.0	Mar. 69 - Feb. 72
W. Garrison Powell Co.	15.3	1.7	5.9	14.5	60.4	0.0	Mar. 69 - Feb. 72
Jens Powell Co.	12.3	0.5	2.4	10.9	50.4	0.0	Mar. 69 - Oct. 71
S. Garrison Powell Co.	22.4	5.3	7.0	17.3	40.4	0.0	Mar. 59 - Oct. 71
Pistol Range Powell Co.	9.6	2.2	4.2	18.0	25.6	0.0	Mar. 69 - Oct. 71

*Values in PPM

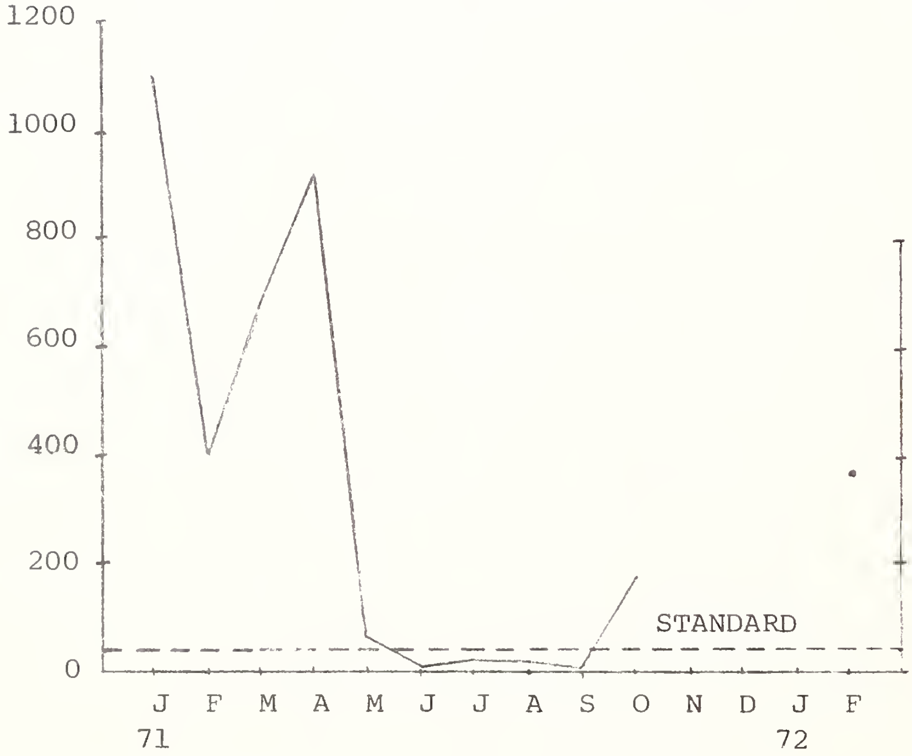
Figure 4.21

Fluoride Data
(Vegetation)

Values in ppm F^-



North Across Highway
Powell County

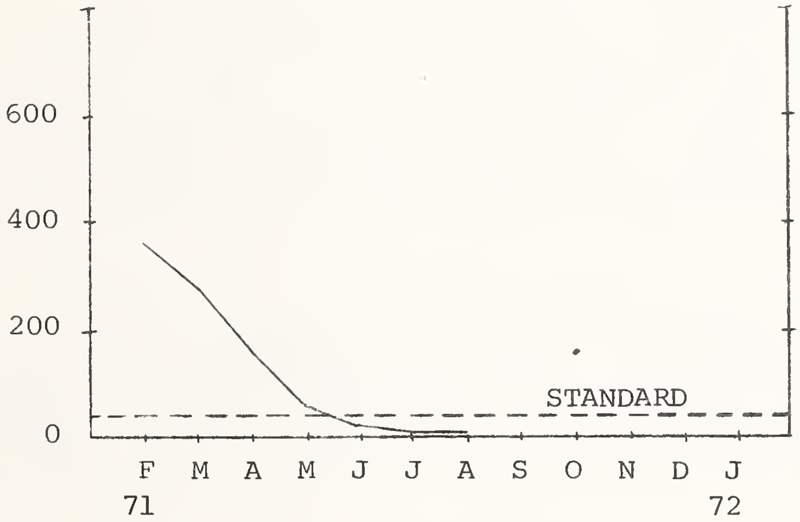


Mullenburg
Powell County

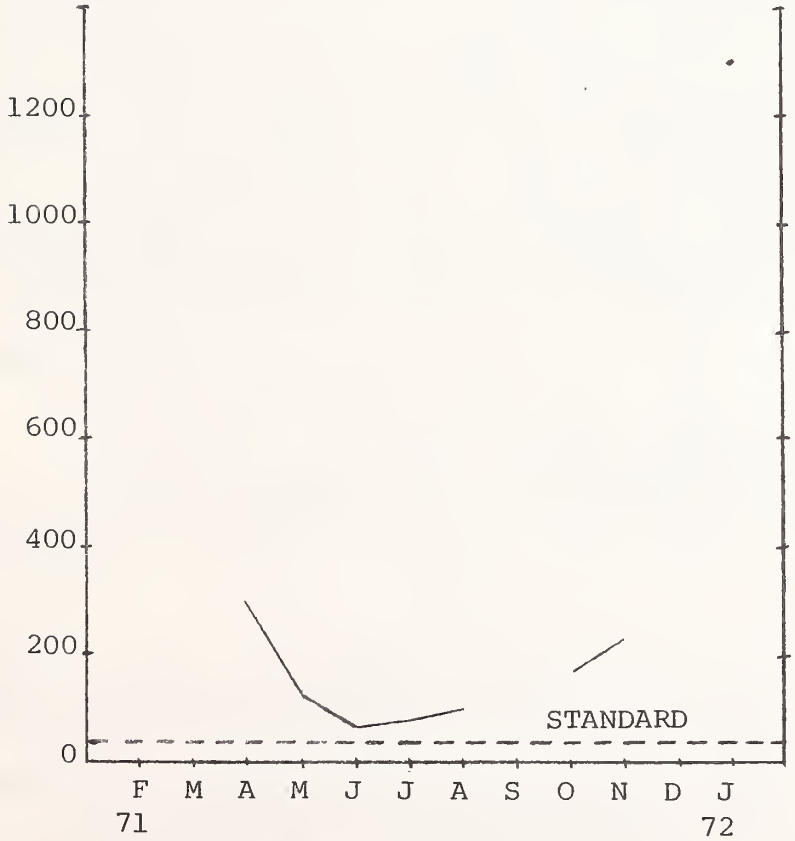
Figure 4.22

Fluoride Data
(Vegetation)

Values in ppm F^-



Silver Bow Exit
Silver Bow County



ESE of Stauffer Chemical
Silver Bow County

5. DISCUSSION OF DATA

5.1 Total Suspended Particulates

In examining total suspended particulate (TSP) data, both the geometric mean (GM) and the geometric standard deviation (GSD) must be considered. Two stations with equal GM but differing GSD will have differing dust problems. The station with the higher GSD will have had an overall lower quality of air. Note should be made here that values presented on the quality of the ambient air refer to the particular sampling site and are not necessarily representative of general air quality for the entire community. In order to be considered worthwhile, for National Air Data Bank (NADB) files (20) , 24-hour sample data such as sampled by high-volume samplers must contain at least 26 samples per year. No quarterly statistics can be considered unless there is a minimum of five samples per quarter. A second constraint is that if one month has no values, there must be at least two values in each of the other two months.

In examining the TSP data for the Deer Lodge Valley, the highest readings are noted for the Butte area. This is realized both in the GM and GSD and in the number of 24-hour readings exceeding the standards set for by Montana and Federal (Table 4.2). The maximum 24-hour reading noted at Webster Garfield School station was 537 micrograms/cubic meter (1971-73). A value of 966 ug/m^3 was recorded at that same station 3/15/74.

In examining the monthly trends of TSP for several of the longer running station, the Anaconda Jr. High station shows a decreasing GM and GSD generally about the same. This indicates that over the period of time this station was operated, the quality of the air as far as TSP is concerned did improve. This also appears to be the case for Ramsay School in Silver Bow County and Lahman residence in Powell County. The monthly trend for Lahman residence shows recurring seasonal patterns with higher values in late summer and fall. The lowest values are noted in January through March. The comparison of past TSP values with the more recent data shows a slight improvement in the ambient air. Decrease in values is greatest in Garrison showing 50% reduction and least in Deer Lodge and Butte showing 10% and 13% reduction, respectively. The arsenic levels also show decreases except at Garrison where a slight increase is noted. Levels of lead show extreme increases at all the locations except at Anaconda where a decrease is shown. Highest concentrations of the trace element analysis were for zinc and lead. The highest zinc concentrations were found in the Anaconda and Deer Lodge County area. The highest reading of lead was found in the Butte area.

5.2 Settleable Particulates

Settleable particulates (dustfall) are the heavier particles in the air. These particles then settle out of the air close to the source of generation and therefore, depend very little on inversion conditions. Common sources of dustfall are wind blown dust, dust raised by the normal activities of a community, dust from unpaved streets and partially burned particles from poor burning practices such as open burning and poorly operated tepee burners. Dustfall samples are collected every month and 2 samples are required every quarter to be considered valid for NADB files.

Highest readings are noted in the Philipsburg area. Here the major contributors, as mentioned previously are two tepee burners. The Montana standard of 15 tons per square mile was violated quite often as shown in the monthly trend graphs. Seasonal statistics vary with each station. Very little can be interpreted about the trend for these stations as too little data is available.

5.3 Sulfur Dioxide

Relatively good sulfur dioxide data is available for the Anaconda area. Because The Anaconda Company is the major source of SO_2 in the valley, all of the continuous analyzers operated in the valley during this period were located in Deer Lodge County. The Poor Farm station, operated the longest, provides the best continuous data. Table 4.7 shows 56 1-hour readings exceeded the 0.25 ppm standard set by Montana. Also 5 24-hour averages exceeded the 0.10 ppm standard. Close to 8000 out of nearly 11,000 possible readings were recorded. To be considered valid for NADB files, 75 percent of individual values must be present before either quarterly or yearly statistics can be used. Figure 4.7, showing a comparison of readings averaged over varying time lengths, shows the Poor Farm as having the highest readings for the shorter time periods. Examination of wind roses for the Anaconda area shows the predominant wind is out of the west or southwest. This would indicate that the majority of the SO_2 samples should be northeast to east of the main Anaconda stack. The Poor Farm station is located some 5 miles NNE of the main stack.

5.4 Sulfation Rate

Sulfation rates measure the reactive sulfur compounds, mostly sulfur dioxide, in the air. Sulfur oxides are generally produced by combustion of fossil fuels, oil and gasoline. Sulfation rates for Deer Lodge County are high compared to the monthly standard. In Powell County, values are lower and never exceed the standard at the stations shown. Comparisons of the Willow Glenn sulfation rate and monthly sulfur dioxide readings as measured by continuous analyzers show a correlation of 0.81. Comparisons of production figures for the Anaconda Company and sulfation rate figures show a very good correlation. A marked decrease in sulfation measured in the Deer Lodge County area coincided with a strick which halted operations at the Anaconda smelter.

5.5 Fluorides in the Air

Fluorides in the valley were measured by three methods. These were Ca Formate papers, Na Formate plates, and vegetation samples. Standards vary for the method of measurement (see Appendix III). Values were highest for the Stauffer Chemical Company area and the area around Rocky Mountain Phosphates, Inc. The graphs show both areas increased in fluorides measured in the air over the period sampled. Rocky Mountain Phosphates, Inc. ponds also were very high in fluorides as was vegetation sampled in the area. Data for these areas show a degradation in the quality of the air toward the end of 1973. Comparison of Stauffer Chemical Company production figures with Ca Formate papers and Na Formate plates from the station ESE of the plant show a good correlation with the low fluoride values occurring during the times of low production. The increase in fluoridation around Rocky Mountain Phosphates, Inc. also agrees very well with the increased production at the plant.

6. BUTTE AREA PARTICLE STUDY

A particle study was made in the Butte area from Feb-Apr, 1974. The study was conducted to determine size, amount, and chemical composition of the suspended particles in the Butte ambient air. High volume samplers were located at four sites in the area. These were at Greeley School, Atkins Residence, Harrison School and Columbia Gardens. At Harrison School there was also located a high-volume cascade samplers, a nephelometer, particulate tape sampler, and a membrane sampler.

The high-volume sampler results for the four sites are shown in Table 6.2. Geometric means for the sites show the Greeley School as having the highest suspended particulate concentration with Harrison School also having a fairly high concentration. Table 6.3 shows the relative distance and direction of the sites from the Berkeley Mine perimeter. This comparison shows that the two sites with the highest concentrations are also the two sites closest to the mine perimeter. Figures 6.1 through 6.4 show plots of cumulative probability of total suspended particulate values at the four sites in Butte. Median values (50%) show largest concentrations at Greeley School (150 ug/m^3) and lowest concentrations at Atkin residence (20 ug/m^3). The highest predicted concentrations from the graphs are Greeley School (1300 ug/m^3), Atkin residence (170 ug/m^3), Harrison School (370 ug/m^3), and Columbia Gardens (160 ug/m^3).

Even though the Harrison School samplers were closer to the Berkeley Pit operation, they were probably somewhat sheltered from the wind.

At the Harrison School in Butte, a more intense particle study was performed than at the other three sites in Butte. At the Harrison School, studies were made on optical density and concentration of haze (particulate tape sampler), visibility (nephelometer), relative humidity, total suspended particulate (high volume sampler), particle size (high volume cascade impactor), and particulate trace element analysis (membrane sampler). Results from several of the samplers are shown in Table 6.4. Concentration of haze (COH) is in units of COH per 1000 linear feet of air sampled through a one inch area spot on the tape sampler. The relative humidity is from the East Anaconda station operated by the Anaconda Company. The variables in the table are all related in that any one can be affected by one or more of the others. Low visibility can be due to high relative humidity or high total suspended particulates (mostly affected by particles less than 2 microns). The same is true of optical density and concentration of haze. Very high particulate values and very low visibilities are evident from the table.

In Table 6.5, a comparison was made of particle sizes at Harrison School, Butte and two sampling sites at Colstrip, Montana. Values in parentheses are percentages of the total micrograms per cubic meter for the different particle sizes. The results show that the Harrison School ambient air has many times more particulates of all sizes. Also it is evident that in the Bute ambient air, the majority of the particles are large whereas in Colstrip the smaller particles dominate. Comparisons of relative humidity and visibility shows that Colstrip, even with a higher relative humidity, has a visiblity over ten times that at Butte.

Comparisons of reduced visiblity with traffic patterns in Butte shows very little correlation. Correlations with relative humidity show a fair correlation but still leave a factor in the correlation unexplained. This unexplained factor probably is the open pit mining activities.

Figure 6.5 shows the comparison of particle sizes for the two areas once again only on log probability graph paper. The verticle axis indicates particle size while the horizontal axis indicates the cumulative percent of mass less than a given particle size. The graph shows that the mass mean diameter (MMD) or 50% value for Butte is 7.0 microns where at Colstrip it is only 2.5 microns. This once again shows that the larger particles dominate at Butte whereas the smaller particles dominate at Colstrip.

Table 6.1 indicates the area of the respiratory system reached and affected most by the different particle sizes. One might hasten to conclude that since the larger particles dominate at Butte, the particles will not affect the lower respiratory tract as much as the particles at Colstrip. This would be false as Table 6.5 shows that the Butte area air has many times more particles than Colstrip in all size categories.

Analyses were also performed on membrane filters to determine the trace elements in the suspended particulates in the Harrison School ambient air. Table 6.6 show the results of this study. Missing values indicate values were below the detection limits of the instrument. Values are in micrograms per cubic meter.

Table 6.1
Particle Size Affecting Respiratory System Area (18)

Particle Size (microns)	Area Reached and Affected
7.0 and above	Nasopharnyx area
3.3 - 7.0	Trachea and primary bronchi
2.0 - 3.3	Secondary bronchi
1.1 - 2.0	Terminal bronchi
Submicron	Alveoli (CO_2 and O_2 transfer area)

Highest values were recorded for iron (Fe) and zinc (Zn). Very low levels were reocrded for berylium (Be) and chromium (Cr) with berylium never reacing high enough concentrations to be measured.

Summary

The results of the Butte area particlate study show unusually high suspended particulate concentrations. Comparisons with Colstrip ambient air, normally considered very clean background air, show very extreme differences with total suspended particulate concentrations in Butte more than ten times that in Colstrip. HIgh concentrations of particles less than 1.0 microns are also noted in the Butte ambient air. These are the particles that affect the alveoli or CO_2 and O_2 exchange areas. Comparisons of visibilities show that the Butte ambient air has an average visiblity of less than one-tenth that of Colstrip.

High concentrations of iron and zinc in trace element analysis were also found in the Butte area.

Table 6.2

Butte Area Total Suspended Particulate Data
Period: 2/1/74 - 4/15/74
Values in micrograms/cubic meter

Greeley School		Atkins Res.		Harrison School		Columbia Gardens	
2/25	255	2/4	10	2/22	247	2/25	15
2/28	80	2/11	24	2/25	141	2/28	36
3/3	51	2/22	31	2/28	103	3/2	31
3/6	29	3/1	7	3/3	184	3/5	16
3/15	966	3/6	6	3/6	44	3/14	53
3/18	85	3/12	34	3/9	350	3/17	119
3/21	131	3/18	27	3/11	149	3/20	50
3/24	74	3/25	66	3/15	178	3/23	10
3/27	367	3/30	22	3/18	69	3/26	17
3/30	135	4/5	124	3/21	160	3/30	19
4/3	205	4/11	16	3/24	174	4/3	36
4/5	560			3/27	113	4/5	49
4/8	519			3/30	59	4/8	81
4/12	270			4/5	136	4/12	77
				4/8	191		
				4/12	69		
Geometric Mean	171.5		22.7		129.4		34.2

Table 6.3

Butte Area High Volume Sampler Stations

Site Location	Height Above Ground (m)	Distance & Direction From Mine Perimeter
Greeley School	4	0.77 mile SE
Atkins Residence	1	0.95 mile WNW
Harrison School	4	0.50 mile ESE
Columbia Gardens	1	2.1 miles ESE

Figure 6.1

Greeley School
Butte, Montana
Total Suspended Particulates

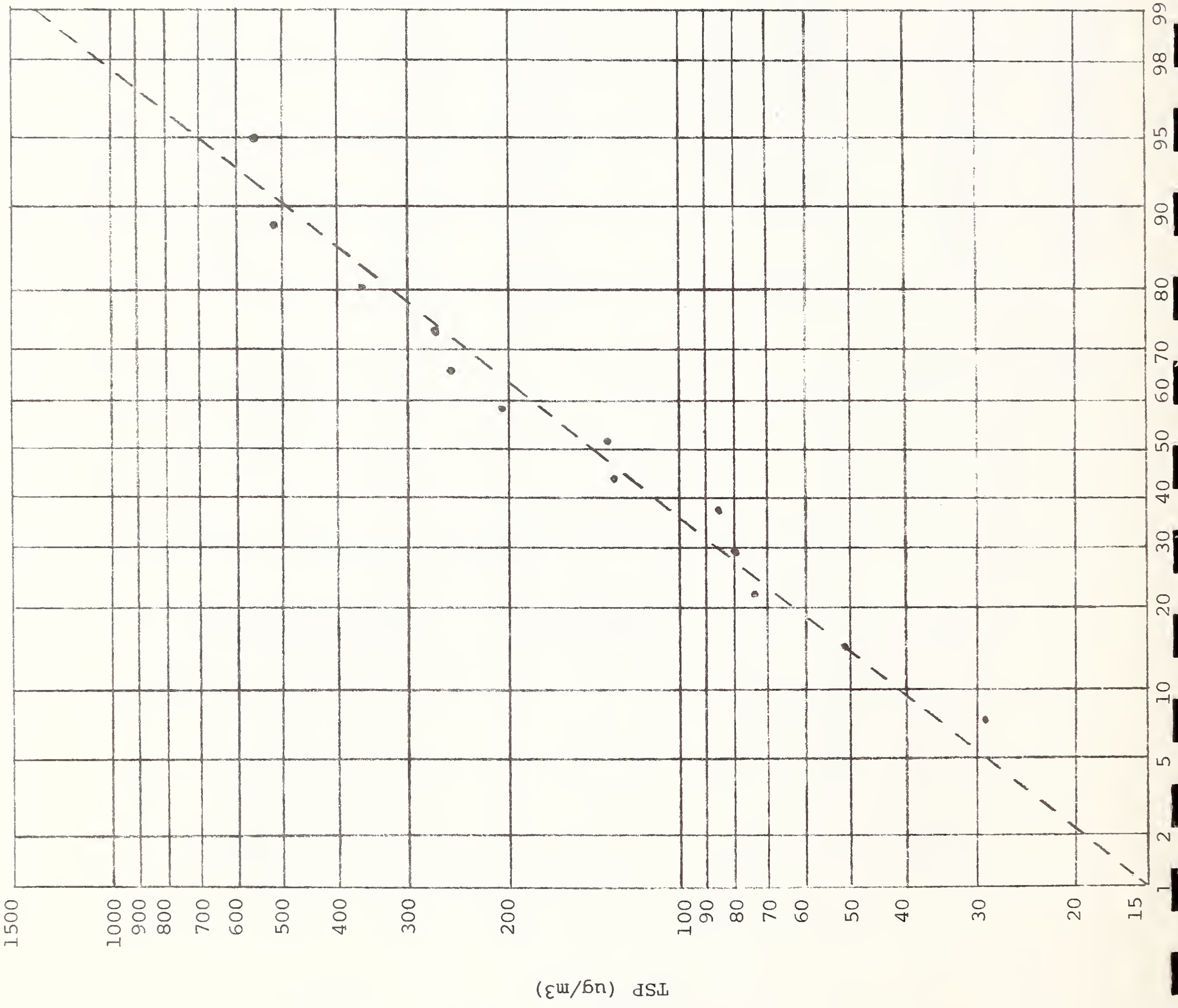


Figure 6.2

Atkin Residence
Butte, Montana
Total Suspended Particulates

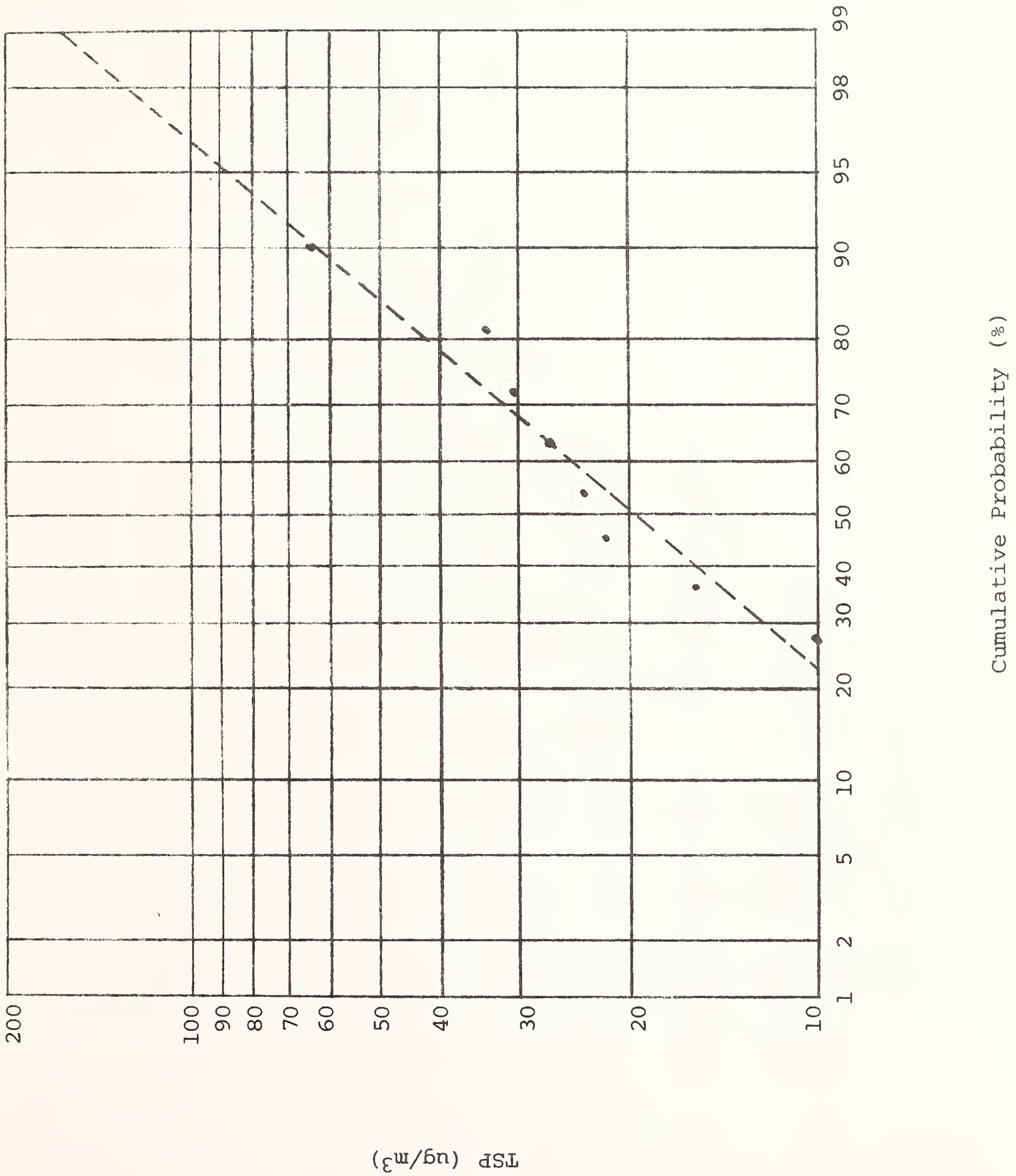


Figure 6.3

Harrison School
Butte, Montana
Total Suspended Particulates

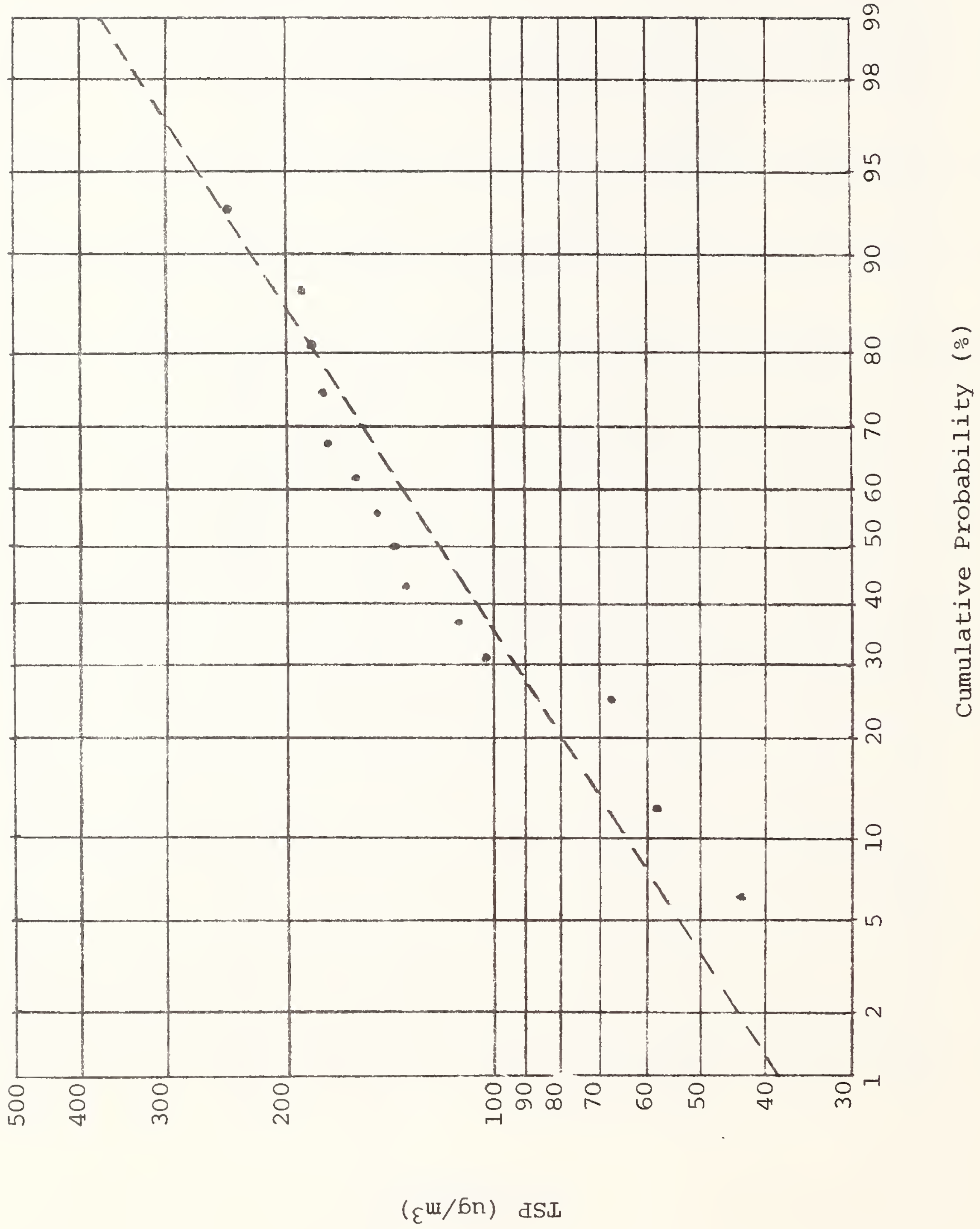


Figure 6.4

Columbia Gardens
Butte, Montana
Total Suspended Particulates

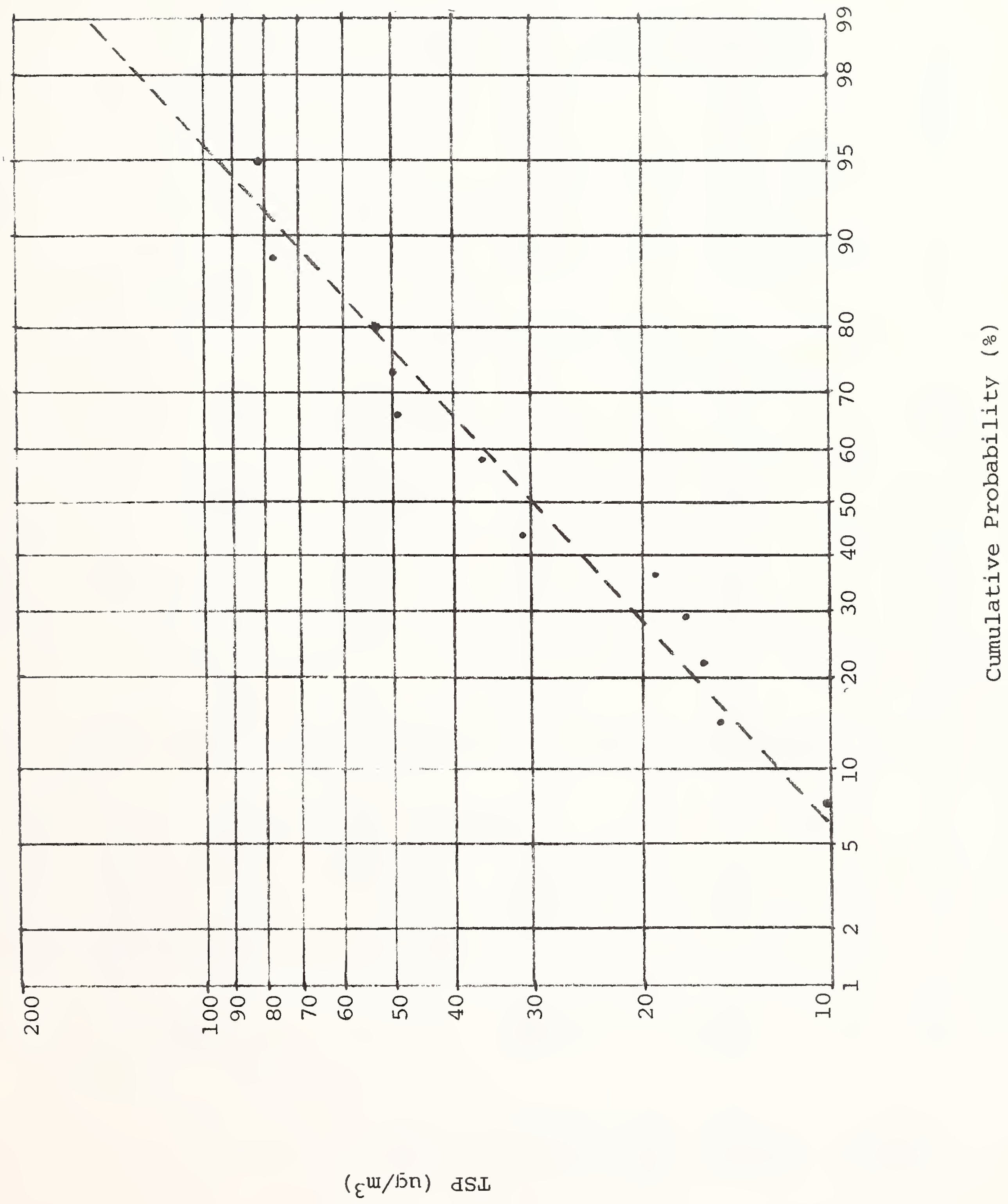


Table 6.4

Particulate Data From Harrison School, Butte
Period Feb - Apr, 74

Date	Optical Density	Concen. of Haze/1000ft.	Visibility (miles)	RH* (%)	Hi-Vol (ug/m^3)	Cascade (ug/m^3)	
						Total	Part. < 2u
2/11	0.79	9.5	13.3	40.2	--	122	49.9
2/14	0.94	11.3	26.5	52.7	--	138	36.8
2/22	1.22	14.7	91.3	55.5	247	245	58.1
2/25	1.19	14.3	43.6	35.6	141	301	55.3
2/28	2.35	28.2	116.8	50.2	103	121	18.9
3/3	1.19	14.3	67.9	47.3	184	--	--
3/6	--	--	73.0	46.7	44	--	--
3/9	--	--	18.4	46.5	350	--	--
3/11	--	--	23.5	38.1	149	94	30.6
3/15	0.87	10.4	33.6	53.9	178	181	29.7
3/18	1.10	13.2	44.9	49.9	69	152	28.2
3/21	1.07	12.8	42.9	47.8	160	305	125.7
3/24	1.17	14.0	24.1	63.0	174	146	33.9
3/27	1.21	14.5	42.3	56.8	113	119	34.0
3/30	--	--	37.4	72.4	59	79	28.7
4/2	--	--	63.5	57.8	--	99	27.7
4/5	1.30	15.6	39.5	48.9	136	144	36.5
4/8	1.17	14.0	--	36.5	191	183	47.2
4/12	--	--	--	48.8	69	118	38.1
4/15	1.08	14.4	--	28.2	--	109	33.4

*Relative humidity data from East Anaconda

Table 6.5

Arithmetic Average Particulate Data for Butte and Colstrip, Montana
Period: 2/1/74 - 4/15/74

	Harrison School Butte	Colstrip (2 sites)
Hi-Vol (ug/m3)/no. samples	147.9/16	9.9/47
Cascade (ug/m3):		
Part. 7u & >	70.6 (44.6)*	3.4 (25.3)
3.3 - 7u	27.4 (17.7)	2.9 (20.9)
2.0 - 3.3u	16.9 (10.7)	1.2 (9.4)
1.1 - 2.0u	9.9 (6.3)	2.0 (13.4)
submicron	32.0 (21.0)	4.1 (31.0)
Total/no. samples	156.8/17	13.6/12
Relative humidity(%)[a]	56.5+	81.1
Visibility (miles)[b]	35.2	364.0

*Values in parenthesis are percentages of the total micrograms per cubic meter.

+Relative humidity data from East Anaconda

[a] Relative humidity recorded for 3/1/74 - 3/31/74

[b] Visibility data for Feb and Mar, 1974

Figure 6.5

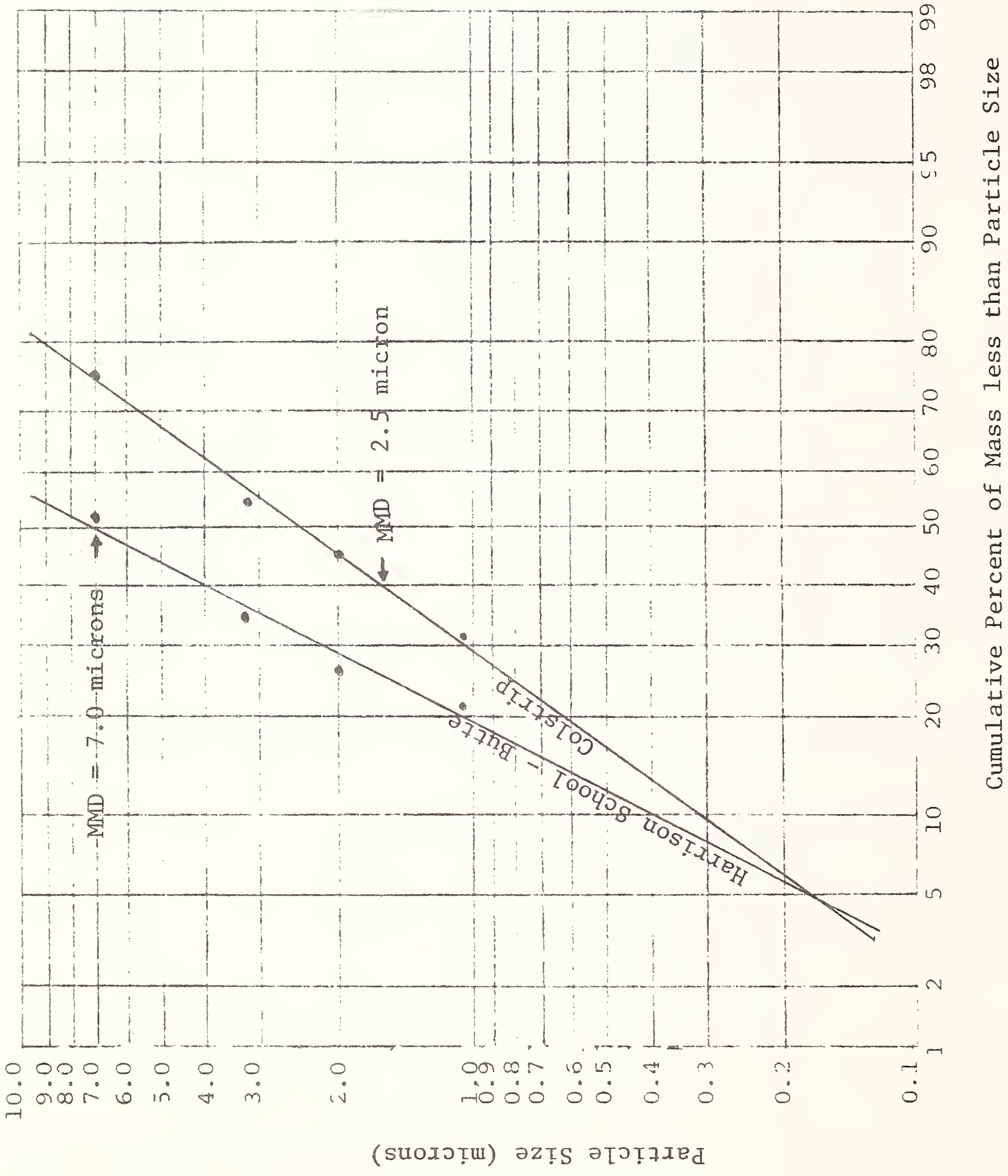

MMD = 7.0 microns
MMD = 2.5 micron
Colstrip
Harrison School - Butte
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Particle Size (microns)
1
2
5
10
20
30
40
50
60
70
80
90
95
98
99
Cumulative Percent of Mass less than Particle Size

Table 6.6

Membrane Filters (Trace Element Analysis)

Harrison School, Butte

(Values in $\mu g/m^3$)

Date	Be	Fe	Zn	Ni	Cr	V	Mn
3/15/74	--*	9.00	1.10	0.004	--	0.015	0.001
3/18	--	2.00	0.70	--	--	--	--
3/21	--	0.62	0.32	--	--	--	--
3/24	--	6.30	1.20	0.003	--	--	--
3/27	--	5.20	0.53	--	--	--	--
3/30	--	2.40	0.52	0.003	0.003	--	0.061
4/2	--	3.60	0.81	0.003	0.004	--	0.083
4/5	--	4.70	0.34	0,003	0.008	--	0.120
4/8	--	7.00	0.75	0.006	0.010	--	0.200
4/12	--	2.50	0.29	0.006	0.002	--	0.060

*Missing values indicate below detection limit of the analysis method used

7. DIFFUSION MODELING ESTIMATES

7.1 Background

A short-term diffusion model was run to estimate ground level concentrations of air pollution from two sources in the valley. The model utilizes Pasquill(19) dispersion equations and also Brigg's (20) plume. rise equations. The plume is assumed to be of Gaussian distribution. Concentration estimates were made for a series of 16 radial transects extending from a source center. The 16 directions are given in Table 7.1. Along each of the radials, seven equidistant receptor points are located. Elevations of these points were extracted from U.S. Geological Survey maps. Ground level concentrations were then calculated at each of these points for varying wind speeds and stability conditions. The computer model then picked the conditions that would result in maximum concentrations for each point. These values were then printed out in tabular form. Winds were assumed to blow at each direction of the 16 radials for the period used. This is a valid assumption since no comparison is made of each point with another. The meteorological conditions at each point would probably occur on different days in the year.

Table 7.2 shows meteorological conditions and comparative stabilities generally associated with each stability category of the model. Unstable conditions in the atmosphere are when the temperature decreases with height above ground greater than 5.4°F per 1000 feet. (Stability used in calculations in the diffusion model is dependent on the change in potential temperature with height instead of actual temperature. Potential temperature is the temperature obtained when a parcel of air is brought adiabatically to a pressure of 1000 millibars). Unstable conditions generally occur on sunny days when the ground becomes heated and warms the air above. Wind speeds are low and directions variable. Atmospheric pollutants are readily dispersed. If the temperature decreases with height about 5.4°F per 1000 feet, the stability condition is considered neutral. Such conditions are normal during cloudy, windy days where thorough mixing occurs. Wind directions aremore or less steady. Atmospheric pollutants are dispersed relatively well. If the temperature decreases with height less than 5.4°F per 1000 feet, the stabiltiy condition is considered stable. As the rate of temperature decrease approaches zero or greater, the atmospheric dispersion rate also decreases. If the temperature increases with height, the condition is called an inversion. Such conditions usually occur on clear or partly cloudy nights with light or calm winds. Such conditions can also prevail into the daytime hours.

Mountain valleys such as the Deer Lodge Valley are particularly subject to intense and long-lasting inversion conditions. The air in the valley and its tributaries is less dense than air at lower elevations and therefore presents less of a barrier to outgoing radiation. Winter nights in this area are relatively long, allowing more radiation to escape. Also the mountains surrounding are a barrier to strong winds which would mix and destroy the inversion. Snow cover during the winter season also reflects solar radiation and is an excellent radiator of heat at night. Also, cool air drains to lower elevations because of its greater density and, therefore, causes deeper and more intense inversions in a valley than would occur on level ground.

Table 7.1
DEGREES OF COMPASS CORRESPONDING TO THE DIRECTION NUMBER FOR THE DIFFUSION MODELING RESULTS

Direction	Degrees of Compass	Direction	Degrees of Compass
1	0 or 360	9	180.0
2	22.5	10	202.5
3	45.0	11	225.0
4	67.5	12	247.5
5	90.0	13	270.0
6	112.5	14	292.5
7	135.0	15	315.0
8	157.5	16	337.5

Table 7.2
METEOROLOGICAL CONDITIONS AND PASQUILL STABILITY CLASSES (19) CORRESPONDING TO THE STABILITY CATEGORY FOR DIFFUSION MODELING RESULTS

Stability Cagetory	Pasquill Stability Class	Comparative Stabiltiy	Meteorological Conditions	
1	A	Extr. Unstable	Wind speeds 3m/sec or less	Daytime insolation mod. to strong
2	B	Mod. Unstable	Wind speeds less than 4m/sec	Daytime insolation strong to mod.
3	C	Slightly Unstable	Wind speeds less than 6m/sec	Daytime insolation mod. to strong
4	D	Neutral	All wind speeds	Daytime insolation slight
5	E	Slightly Stable	Wind speeds less than 4.5m/sec	Nighttime insolation moderate outgoing
6	F	Mod. Stable	Wind speeds usually less than 3m/sec	Nighttime insolation strong outgoing

Topography also greatly affects the travel of plumes from stacks in the area and, therefore, also greatly affects the ground level concentrations of atmospheric pollutants. Air is channeled by a valley especially during stable conditions. A plume is confined by a valley and will follow the walls as it travels. In doing so plumes will intersect ridges that project into the valleys and consequently on these exposed areas facing the pollution source will receive high concentrations. Because of the channeling, high ground concentrations can occur at greater distances downwind of a source that would normally occur in flat terrain.

7.2 Rocky Mountain Phosphates, Inc.

The first model estimates were for the emissions from the Rocky Mountain Phosphates, Inc. located at Garrison, Montana. The two sources of air pollution modeled were the stack and the settling ponds. The plant elevation used was 4353 feet msl. The pond was estimated to be 0.75 acre and emitted fluoride at the rate of 0.04 grams/sec. This figure was calculated from a study by the University of Florida on fluoride emissions from gypsum ponds. (21) The lowest emission rate they measured was 10.8 lbs/acre/day or 0.056 grams/sec/acre. Converting to Rocky Mountain Phosphates, Inc., an emission rate of 0.04 grams/sec was used. Other parameters used are given in Table 7.3. The concentrations were calculated for 24-hour periods to compare with the Montana standard of 1 ppb 24-hour average. The receptor points are in one kilometer intervals and the ambient temperature used was 40.0°F (The Garrison normal annual mean temperature). The stability parameters used for the plume rise equations were $0.000159/sec^2$, a less stable case, and $0.000163/sec^2$, a more stable case. The two parameters are for cases that can occur quite frequently in the valley and would be considered conservative in the estimates they calculate.

Table 7.3

	Pond	Stack
Elevation (above ground)	0.00 ft.	204.0 ft.
Top inside radius	328.0 ft.	1.2 ft.
Exit Temperature	40.0°F	100.0°F
Exit Velocity	0.0 m/sec	15.9 m/sec
Emission Rate	0.04 g/sec	0.01 g/sec

Maximum values for the pond and stack individually and the combined sources are given in Table 7.4 through 7.9. Values are in parts per billion (ppb) of fluoride.

This first modeling results assume possible impaction of the plume center line with terrain (Pasquill categories E & F only). The plume is assumed to be of Gaussian distribution in the vertical and horizontal directions with maximum concentrations at the center. Therefore, maximum concentration estimates will occur when the plume center-line impacts the terrain. Results of the model show values of combined sources exceeding the Montana standard by five times. Highest readings are estimated within 1 kilometer or 5/8 miles of the plant. The wind speed are mainly light with the average approximately 2 m/sec or

4.5 miles/hr. Stability is generally the moderately stable category. The individual source contributions indicate the pond is the major source of the fluoride.

Table 7.10 shows results of the model assuming no impaction of the plume center-line with terrain. This is assumed to occur in stability categories A-D only. Results of the model show ground level estimates well below the Montana standard with the maximum of 0.0037 ppb. The assumption of no impaction of the center-line of the plume with the terrain is not very realistic in the case of Rocky Mountain Phosphates, Inc. as the emissions from the pond have relatively zero exit velocity and are of more of a drifting motion than a stack plume.

Since there is no bouyancy effect associated with the emissions from the pond, concentrations exceeding those given for the 1 km interval could be conceived closer to the pond than 1 km. Since the objective of this modeling was not to find the conditions of the highest possible concentration estimate, this was not done. The purpose of the modeling was only to show the relative magnitude of the concentration estimates that could be conceived from the source.

7.3 Anaconda Company

The second model run was for the emissions from the Anaconda Company's main stack at Anaconda, Montana. The plant elevation used was 5420 feet msl. Other parameters used are given in Table 7.11. Concentration estimates were made for sulfur dioxide for 1-hour periods to compare with the Montana standard of 0.25 ppm not to be exceeded more than one hour in any 4 consecutive days. The receptor points are at 4 kilometer intervals. The ambient temperature used was 42.8°F (normal annual mean). The stability parameters used once again were $0.000159/\text{sec}^2$, which is the less stable case, and $0.000163/\text{sec}^2$, the more stable case.

Table 7.11

	Stack
Elevation	584.0 ft.
Top Inside Radius	60.0 ft.
Exit Temperature	220.0°F
Exit Velocity	3.19 m/sec
Emission Rate	7581.0 g/sec

The emission rate was determined from Section 2.1.

Maximum values for the stack are given in Tables 7.12 and 7.13. Values are in parts per million (ppm) of sulfur dioxide. The first modeling results assume possible impaction of the plume center-line with terrain. Using this assumption, the model predicts maximum ground level concentrations of 6.7 ppm at 8 km WSW of the plant with the less stable case and concentrations of 8.8 ppm at 4 km and 9.3 at 8 km WSW of the plant and 8.3 ppm at 12 km SW of the plant. The estimates are for generally light to moderate wind speeds and stable atmospheric conditions. These estimates show ground level concentrations well in excess of the Montana and Federal primary standards for sulfur dioxide. Estimates once again are only to show relative magnitudes and different estimates could have been calculated had low level emissions from the plant been included. Also variations would have resulted had the conversion of sulfur dioxide to suspended sulfates been included.

Table 7.14 shows estimates of ground level concentration of SO_2 at the AnacondaCompany copper smelter if no impaction of plume center-line with terrain was assumed. In the more stable case, violations once again are noted with estimates reaching 0.373 ppm. This case occurs only in the unstable to neutral stability classes.

In both cases, impaction or no impaction of plume center-line with terrain, much higher concentrations could be conceived had more stable plume rise parameters been used. The stability parameters used (0.000159 and 0.000163) are for cases that can occur frequently in the Deer Lodge Valley.

7.4 Comments Pertaining to Both Modeling Results

Values of both models for the stable cases are high and greatly exceed the Montana and Federal standards. It should be stated though that predicted concentrations may not agree with actual measured values even if monitors are located at the same receptor points of the model and atmospheric conditions of both model and actual measured values agree. This can be due to pecularities in the terrain which can alter the air flow, or to the varying of atmospheric conditions during the length of time elapsed from release until impaction with the terrain of the plume. Also since this is a simplified model, the estimates are only shown as relative magnitudes that can be realized at present emissions under meteorological conditions that can occur quite frequently in the area. The model does not take into account mixing due to upslope or downslope air currents, conversion of SO_2 to suspended sulfates, or many other factors which could alter the actual measured ground level concentrations. The main objective of this diffusion modeling is to show the relative magnitude of ground level concentrations that could occur under reasonable atmospheric conditions.

Table 7.4

24-Hour Diffusion Modeling Results for Rocky Mountain Phosphates, Inc.

(Results are Maximum Concentrations of Fluoride Realized from the Main Stack)[1]

Direction	1 Km	2 Km	3 Km	4 Km	5 Km	6 Km	7 Km
1	--	0.1(3)(6)*	0.1(3)(6)	0.1(2)(6)	--	--	--
2	--	0.2(3)(6)	0.1(2)(6)	--	--	--	--
3	--	--	0.1(2)(6)	--	--	--	--
4	--	--	--	0.1(2)(6)	--	--	--
5	--	--	--	0.1(2)(6)	0.1(2)(6)	--	--
6	--	--	--	--	--	--	--
7	--	--	--	--	--	--	--
8	--	--	--	0.1(2)(6)	0.1(2)(6)	--	--
9	--	--	0.1(2)(6)	--	--	--	--
10	--	--	--	--	0.1(2)(6)	0.1(2)(6)	--
11	--	0.2(2)(6)	--	--	0.1(2)(6)	--	--
12	--	--	--	0.1(2)(6)	0.1(2)(6)	0.1(2)(6)	--
13	--	0.1(6)(6)	--	0.1(2)(6)	--	0.1(2)(6)	--
14	0.3(4)(6)*	--	--	--	--	--	--
15	--	--	--	--	--	--	--
16	0.3(4)(6)	0.1(6)(6)	--	--	--	0.1(2)(6)	--

*Value predicted in PPB (wind speed in meter/sec+) (stability category)

+1 meter/sec = 2.2 miles/hr

-- missing values indicate concentrations less than 0.05 PPB.

[1] 0.000159 plume rise stability parameter

Table 7.5

24-Hour Diffusion Modeling Results for Rocky Mountain Phosphates, Inc.

(Results are Maximum Concentrations of Fluoride Realized from the Ponds)[1]

	Distance from Source						
Direction	1 Km	2 Km	3 Km	4 Km	5 Km	6 Km	7 Km
1	0.1(2)(5)*	--	--	--	--	--	--
2	0.2(2)(5)	--	--	--	--	--	--
3	1.2(2)(5)	0.3(2)(5)	--	--	--	--	--
4	3.2(2)(6)	0.9(2)(6)	0.1(2)(5)	--	0.1(2)(5)	0.1(2)(5)	0.1(2)(5)
5	5.1(2)(6)	2.0(2)(6)	1.0(2)(6)	--	--	--	--
6	5.0(2)(6)	0.1(2)(5)	0.1(2)(5)	0.1(2)(5)	0.1(2)(5)	--	0.1(2)(5)
7	4.4(2)(6)	1.6(2)(6)	1.1(2)(6)	0.1(2)(5)	0.1(2)(5)	0.3(2)(6)	0.3(2)(6)
8	5.1(2)(6)	2.0(2)(6)	0.2(2)(5)	--	--	--	--
9	5.0(2)(6)	0.6(2)(6)	--	--	--	--	--
10	4.4(2)(6)	0.9(2)(6)	0.3(2)(5)	0.1(2)(5)	--	--	--
11	4.8(2)(6)	--	--	--	--	--	--
12	5.1(2)(6)	2.0(2)(6)	--	--	--	--	--
13	3.2(2)(6)	0.1(2)(5)	0.3(2)(5)	--	--	--	--
14	--	1.5(2)(6)	1.0(2)(6)	0.6(2)(6)	0.2(2)(6)	0.3(2)(6)	--
15	0.1(2)(5)	1.8(2)(6)	1.2(2)(6)	0.8(2)(6)	--	0.2(2)(6)	0.2(2)(6)
16	--	0.1(2)(5)	0.1(2)(5)	0.2(2)(5)	0.3(2)(6)	--	--

*Value predicted in PPB (wind speed in meter/sec+) (stability category)

+1 meter/sec = 2.2 miles/hr

-- missing values indicate concentrations less than 0.05 PPB

[1] 0.000159 plume rise stability parameter

Table 7.6

24-Hour Diffusion Modeling Results for Rocky Mountain Phosphates, Inc.

(Results are Maximum Concentrations of Fluoride Realized from both Sources)[1]

	Distance from Source						
Direction	1 Km	2 Km	3 Km	4 Km	5 Km	6 Km	7 Km
1	0.1(6)(5)*	0.1(3)(6)	0.1(3)(6)	0.1(2)(6)	--	--	--
2	0.2(2)(5)	0.2(3)(6)	0.1(2)(6)	--	--	--	--
3	1.2(2)(5)	0.3(2)(5)	0.1(2)(6)	--	--	--	--
4	3.2(2)(6)	0.9(2)(6)	0.1(2)(5)	0.1(2)(6)	0.1(2)(5)	0.1(2)(5)	0.1(2)(5)
5	5.1(2)(6)	2.0(2)(6)	1.0(2)(6)	0.1(2)(6)	0.1(2)(6)	0.1(2)(5)	--
6	5.0(2)(6)	0.1(2)(5)	0.1(2)(5)	0.1(2)(5)	0.1(2)(5)	--	0.1(2)(5)
7	4.4(2)(6)	1.6(2)(6)	1.1(2)(6)	0.2(2)(5)	0.1(2)(5)	0.3(2)(6)	0.3(2)(6)
8	5.1(2)(6)	2.0(2)(6)	0.2(2)(5)	0.1(2)(6)	0.1(2)(6)	--	--
9	5.0(2)(6)	0.6(2)(6)	0.1(2)(6)	--	--	--	--
10	4.4(2)(6)	0.9(2)(6)	0.3(2)(5)	0.1(2)(5)	0.1(2)(6)	0.1(2)(6)	--
11	4.8(2)(6)	0.2(2)(6)	--	--	0.1(2)(6)	--	--
12	5.1(2)(6)	2.0(2)(6)	--	0.1(2)(6)	0.1(2)(6)	0.1(2)(6)	--
13	3.2(2)(6)	0.1(2)(5)	0.3(2)(5)	0.1(2)(6)	--	0.1(2)(6)	--
14	0.3(4)(6)	1.5(2)(6)	1.0(2)(6)	0.6(2)(6)	0.2(2)(6)	0.3(2)(6)	--
15	0.1(6)(5)	1.8(2)(6)	1.2(2)(6)	0.8(2)(6)	--	0.2(2)(6)	0.2(2)(6)
16	0.3(4)(6)	0.1(2)(5)	0.2(2)(5)	0.2(2)(5)	0.3(2)(6)	0.1(2)(6)	--

*Value predicted in PPB (wind speed in meter/sec+) (stability category)

+1 meter/sec = 2.2 miles/hr

-- missing values indicate concentrations less than 0.05 PPB

[1] 0.000159 plume rise stability parameter

Table 7.7

24-Hour Diffusion Modeling Results for Rocky Mountain Phosphates, Inc.

(Results are Maximum Concentrations of Fluoride
Realized from the Main Stack)[1]

Direction	1 KM	2 Km	3 Km	4 Km	5 Km	6 Km	7 Km
1	--	0.2(2)(6)*	0.1(2)(6)	--	--	--	--
2	--	0.2(2)(6)	--	--	--	--	--
3	--	--	--	--	--	--	--
4	--	--	--	0.1(2)(6)	--	--	--
5	--	--	--	0.1(2)(6)	0.1(2)(6)	--	--
6	--	--	--	--	--	0.1(2)(6)	--
7	--	--	--	--	--	--	--
8	--	--	--	0.1(2)(6)	0.1(2)(6)	--	--
9	--	--	--	--	--	--	--
10	--	--	--	--	0.1(2)(6)	--	--
11	--	0.2(2)(6)	--	--	0.1(2)(6)	--	--
12	--	--	--	--	0.1(2)(6)	--	--
13	--	--	--	0.1(2)(6)	--	--	--
14	0.3(3)(6)*	--	--	--	--	--	--
15	--	--	--	--	0.1(2)(6)	--	--
16	0.2(4)(6)	--	--	--	--	0.1(2)(6)	--

*Value predicted in PPB (wind speed in meter/sec+) (stability category)

+1 meter/sec = 2.2 miles/hr

-- missing values indicate concentrations less than 0.05 PPB

[1] 0.000163 plume rise stability parameter

Table 7.8

24-Hour Diffusion Modeling Results for Rocky Mountain Phosphates, Inc.

(Results are Maximum Concentrations of Fluoride
Realized from the Ponds)[1]

Direction	Distance from Source						
	1 Km	2 Km	3 Km	4 Km	5 Km	6 Km	7 Km
1	0.1(2)(5)*	--	--	--	--	--	--
2	0.2(2)(5)	--	--	--	--	--	--
3	1.2(2)(5)	0.3(2)(5)	--	--	--	--	--
4	3.2(2)(6)	0.9(2)(6)	0.1(2)(5)	--	0.1(2)(5)	0.1(2)(5)	0.1(2)(5)
5	5.1(2)(6)	2.0(2)(6)	1.0(2)(6)	--	--	--	--
6	5.0(2)(6)	0.1(2)(5)	0.1(2)(5)	0.1(2)(5)	0.1(2)(5)	--	0.1(2)(5)
7	4.4(2)(6)	1.6(2)(6)	1.1(2)(6)	0.1(2)(5)	0.1(2)(5)	0.3(2)(6)	0.3(2)(6)
8	5.1(2)(6)	2.0(2)(6)	0.2(2)(5)	--	--	--	--
9	5.0(2)(6)	0.6(2)(6)	--	--	--	--	--
10	4.4(2)(6)	0.9(2)(6)	0.3(2)(5)	0.1(2)(5)	--	--	--
11	4.8(2)(6)	--	--	--	--	--	--
12	5.1(2)(6)	2.0(2)(6)	--	--	--	--	--
13	3.2(2)(6)	0.1(2)(5)	0.3(2)(5)	--	--	--	--
14	--	1.5(2)(6)	1.0(2)(6)	0.6(2)(6)	0.2(2)(6)	0.3(2)(6)	--
15	0.1(2)(5)	1.8(2)(6)	1.2(2)(6)	0.8(2)(6)	--	0.2(2)(6)	0.2(2)(6)
16	--	0.1(2)(5)	0.1(2)(5)	0.2(2)(5)	0.3(2)(6)	--	--

*Value predicted in PPB (wind speed in meter/sec+) (stability category)

+1 meter/sec = 2.2 miles/hr

-- missing values indicate concentrations less than 0.05 PPB

[1] 0.000163 plume rise stability parameter

Table 7.9

24-Hour Diffusion Modeling Results for Rocky Mountain Phosphates, Inc.

(Results are Maximum Concentrations of Fluoride
Realized from both Sources)[1]

Distance from Source

Direction	1 Km	2 Km	3 Km	4 Km	5 Km	6 Km	7 Km
1	0.1(2)(5)*	0.2(2)(6)	0.1(2)(6)	--	--	--	--
2	0.2(2)(5)	0.2(2)(6)	--	--	--	--	--
3	1.2(2)(5)	0.3(2)(5)	--	--	--	--	--
4	3.2(2)(6)	0.9(2)(6)	0.1(2)(5)	0.1(2)(6)	0.1(2)(5)	0.1(2)(5)	0.1(2)(5)
5	5.1(2)(6)	2.0(2)(6)	1.0(2)(6)	0.1(2)(6)	0.1(2)(6)	0.1(2)(5)	--
6	5.0(2)(6)	0.2(2)(5)	0.1(2)(5)	0.1(2)(5)	0.1(2)(5)	0.1(2)(6)	0.1(2)(5)
7	4.4(2)(6)	1.6(2)(6)	1.1(1)(6)	0.2(2)(5)	0.1(2)(5)	0.3(2)(6)	0.3(2)(6)
8	5.1(2)(6)	2.0(2)(6)	0.2(2)(5)	0.1(2)(6)	0.1(2)(6)	--	--
9	5.0(2)(6)	0.6(2)(6)	--	--	--	--	--
10	4.4(2)(6)	0.9(2)(6)	0.3(2)(5)	0.1(2)(5)	0.1(2)(6)	--	--
11	4.8(2)(6)	0.2(2)(6)	--	--	0.1(2)(6)	--	--
12	5.1(2)(6)	2.0(2)(6)	--	--	0.1(2)(6)	--	--
13	3.2(2)(6)	0.1(2)(5)	0.3(2)(5)	0.1(2)(6)	--	--	--
14	0.3(3)(6)	1.5(2)(6)	1.0(2)(6)	0.6(2)(6)	0.2(2)(6)	0.3(2)(6)	--
15	0.1(2)(5)	1.8(2)(6)	1.2(2)(6)	0.8(2)(6)	0.1(2)(6)	0.2(2)(6)	0.2(2)(6)
16	0.2(4)(6)	0.1(2)(5)	0.2(2)(5)	0.2(2)(5)	0.3(2)(6)	0.1(2)(6)	--

*Value predicted in PPB (wind speed in meter/sec+) (stability category)

+1 meter/sec = 2.2 miles/hr

-- missing values indicate concentrations less than 0.05 PPB

[1] 0.000163 plume rise stability parameter

Table 7.10

Rocky Mountain Phosphates, Inc. Diffusion Modeling Results
Maximum 24-hour Values of Fluoride
(No Impaction of Center Line of Plume With Terrain Assumed)

Distance KM	Concentration (ppb) Due to Stack			Wind (m/sec)	Pasquill Stab. Class
	Stack	Pond	Both Sources		
1	0.0001	0.0004	0.0005	2.0	A
2	0.0007	0.0030	0.0037	2.0	A
3	0.0003	0.0011	0.0014	2.0	A
4	0.0001	0.0005	0.0006	2.0	A
5	0.0002	0.0008	0.0010	2.0	A
6	0.0003	0.0011	0.0013	2.0	A
7	0.0003	0.0012	0.0015	2.0	A

Table 7.12

HOURLY DIFFUSION MODELING RESULTS FOR ANACONDA COMPANY ANACONDA, MONTANA

(Results are Maximum Concentrations of Sulfur Dioxide Realized from the Main Stack)[1]

Direction	Distance From Source 4 Km	8 Km	12 Km	16 Km	20 Km	24 Km	28 Km
1	--	--	--	--	--	1.6(5.7)(6)	1.5(4.7)(6)
2	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--
4	--	--	--	--	--	--	--
5	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--
7	--	--	--	--	--	--	--
8	--	--	0.1(6.2)(5)	--	0.4(6.2)(5)	0.2(6.2)(5)	--
9	--	--	0.5(6.2)(5)	2.4(6.2)(6)	2.2(4.7)(6)	--	0.1(6.2)(5
10	--	--	--	--	--	--	--
11	--	--	3.6(6.2)(6)	0.2(6.2)(5)	--	--	--
12	0.1(6.2)(5)*	6.7(5.7)(6)	2.7(2.7)(6)	0.4(2.7)(5)	2.2(3.7)(6)	1.8(2.7)(6)	1.6(4.2)(6
13	--	--	4.3(5.2)(6)	1.5(6.2)(6)	2.4(4.7)(6)	1.6(5.2)(6)	1.2(6.2)(6)
14	--	--	--	--	--	0.1(6.2)(5)	--
15	--	--	3.6(6.2)(6)	2.9(4.7)(6)	2.0(5.2)(6)	1.6(5.7)(6)	1.3(5.2)(6
16	--	--	--	2.8(4.2)(6)	2.2(4.7)(6)	1.8(4.7)(6)	1.8(3.2)(6)

*Value predicted in ppm (wind speed in meter/sec+) (stability category)

+1 meter/sec = 2.2 miles/hr

--missing values indicate concentrations less than 0.05 ppm

[1] 0.000159 plume rise stability parameter

Table 7.13

HOURLY DIFFUSION MODELING RESULTS FOR ANACONDA COMPANY ANACONDA, MONTANA (Results are Maximum Concentrations of Sulfur Dioxide Realized from the Main Stack)[1]

	Distance from Source						
Direction	4 Km	8 Km	12 Km	16 Km	20 Km	24 Km	28 Km
1	--	--	--	--	--	2.8(2.7)(6)	0.6(2.7)(5)
2	--	--	--	--	--	--	--
3	--	--	--	--	--	--	--
4	--	--	--	--	--	--	0.2(6.2)(5)
5	--	--	--	--	0.2(6.2)(5)	0.1(6.2)(5)	0.1(6.2)(5)
6	--	--	--	--	--	--	--
7	--	--	--	--	--	--	--
8	--	--	1.5(6.2)(6)	--	2.0(5.2)(6)	0.9(6.2)(6)	0.1(6.2)(5)
9	--	--	3.9(5.2)(6)	5.7(2.7)(6)	0.8(2.7)(5)	0.1(6.2)(5)	0.3(5.7)(5)
10	--	--	0.1(6.2)(5)	--	--	0.2(6.2)(5)	0.1(6.2)(5)
11	--	--	8.3(2.7)(6)	1.3(6.2)(6)	--	0.1(6.2)(5)	0.1(6.2)(5)
12	8.8(6.2)(6)*	9.3(2.7)(6)	--	--	--	--	0.1(2.7)(5)
13	--	--	1.6(2.7)(5)	4.1(3.2)(6)	0.5(2.7)(5)	1.9(2.7)(6)	2.7(2.7)(6)
14	--	--	--	--	--	0.3(6.2)(5)	0.1(6.2)(5)
15	--	--	--	0.9(2.7)(5)	2.2(2.7)(6)	2.8(2.7)(6)	1.7(2.7)(6)
16	--	--	--	0.3(2.7)(5)	0.8(2.7)(5)	0.7(2.7)(5)	--

*Value predicted in ppm (wind speed in meter/sec+) (stability category)
+1 meter/sec = 2.2 miles/hr
--missing values indicate concentrations less than 0.05 ppm

[1] 0.000163 plume rise stability parameter

Table 7.14

Hourly Diffusion Modeling Results for Anaconda Company
Maximum 1-hour Sulfur Dioxide Values
(No Impaction of Center Line of Plume With Terrain Assumed)

0.000159 Plume Rise Stability Parameter

Distance KM	Concentration (ppm) Main Stack	Wind (m/sec)	Pasquill Stability Class
4	0.163	6.2	2
8	0.114	6.2	3
12	0.107	5.7	3
16	0.090	4.2	3
20	0.077	3.2	3
24	0.068	2.7	3
28	0.060	2.7	3

0.000163 Plume Rise Stability Parameter

Distance KM	Concentration (ppm) Main Stack	Wind (m/sec)	Pasquill Stability Class
4	0.373	2.7	2
8	0.260	2.7	3
12	0.245	2.7	3
16	0.187	2.7	3
20	0.141	2.7	3
24	0.109	2.7	3
28	0.086	2.7	3

APPENDIX I

DEFINITIONS

Ambient Air--	The outside air that we breathe.
Arithmetic Mean--	An average value which is typical or representative of a set of data. Specifically, the arithmetic mean ($\bar{x}$) of a set of N numbers X_1, X_2, $X_3 \ldots X_n$ is: $\bar{x} = \frac{X_1 + X_2 + X_3 + \ldots + X_n}{N}$ Example: the arithmetic mean of 4, 10, 6, 3 and 7 is: $\bar{x} = \frac{4 + 10 + 6 + 3 + 7}{5} = 6$
Geometric Mean--	Another method of expressing the average value of a set of data. Specifically, the geometric mean (G) of a set of N numbers X_1, X_2, $X_3 \ldots X_n$ is: The Nth root of the product of the numbers: $G = \sqrt[N]{X_1 \cdot X_2 \cdot X_3 \cdot \ldots \cdot X_n}$ or $G = \log^{-1} (1/N (\log X_1 + \log X_2 + \log X_3 \ldots \log N)$ Example: the geometric mean of 2, 4, & 8 is: $G = \sqrt[3]{2 \cdot 4 \cdot 8} = \sqrt[3]{64} = 4$ Depending on the type of data collected, either the geometric or the arithmetic mean is used, whichever method tends to be more representative of the data.
Micrograms Per Cubic Meter (ug/m^3)-	A standard method of expressing the concentration of a pollutant on a weight basis. 1 microgram = 0.000001 gram.
Particulate Matter--	Any material except uncombined water which exists in a finely divided form as a liquid or a solid at standard conditions of temperature and pressure.
Parts Per Million (ppm)--	A standard method of expressing the concentration of a pollutant on a volumetric basis.

Appendix II

High Volume (TSP) Sampler Stations

County	Municipality	Site No.	Date of Operation	Site Location
Deer Lodge	Anaconda	0020005	2/71--3/72	Anaconda Jr. High
	"	0020006	4/72--11/72	Kirkeby Res.
	--	0400001	10/71	S & N Cement
	--	0400003	11/72--6/73	Kucera Res.
	--	0400021	3/71-11/71	Johnson Res.
	--	0400022	10/71--11/71	Bailey Res.
Silver Bow	Butte	0160001	7/71--3/72	Harrison St. Fire Sta.
	"	0160002	2/71--3/72	Webster-Garfield School
	"	0160003	7/71--3/72	Silver Bow Gen. Hosp.
	"	0160004	2/71--5/71	Whittier School
	"	0160005	2/71--3/72	Greeley School
	"	0160006	2/71--2/72	Courthouse
	"	0160007	1/71--7/71	Old Emerson School
	"	0160010	4/72	McQueen's Addition
	"	0160011	6/73--12/73	Deasy Res. (Atkins)
	--	1480007	2/71--3/72	Ramsay School
Powell	Deer Lodge	0380001	6/71--3/72	Powell Co. Courthouse
	"	0380002	2/71--3/71	City Hall
	--	1260005	5/71--12/73	Lahman Res.
Granite	--	0640005	4/72--12/73	McKinley Res.

Settleable Particulate (Dustfall) Stations

County	Municipality	Site No.	Dates of OPeration	Site Location
Deer Lodge	--	0400004	3/73	Hwy 48 Jct.
	--	0400005	3/73	Lost Creek
	Anaconda	0020005	7/71--3/72	Anaconda Jr. High
	--	0400010	10/71--2/72	Johnson Ranch
Silver Bow	Butte	0160001	7/71--3/72	Harrison St. Fire Sta.
	"	0160002	2/71--3/72	Webster-Garfield School
	"	0160003	7/71--2/72	Silver Bow Gen. Hosp.
	"	0160004	2/71--11/71	Whittier School
	"	0160005	2/71--3/72	Greeley School
	"	0160006	2/71--3/72	Courthouse
	"	0160007	4/71--6/71	Old Emerson School
	--	1480007	2/71--3/72	Ramsay School
Powell	Deer Lodge	0380001	2/71--3/72	Powell Co. Courthouse
Granite	Philipsburg	0640001	2/72--6/73	Berg Motel
		0640002	2/72--9/73	E. of Church
		0640003	2/72--9/73	Whitberg Ranch
		0640004	2/72--9/73	Whitberg Horse Pond
		0640005	9/73	McKinley Res.
		0640006	3/73--9/73	Ousley

Sulfur Dioxide Sampling Stations

County	Municipality	Site No.	Dates of Operation	Site Location
Deer Lodge	--	0400003	11/72--6/73	Kucera Res.
	--	0400009	12/71--2/72	Warm Springs
	--	0400022	10/71--11/71	Bailey Res.
	--	0400026	11/71--1/73	Poor Farm
	--	0400035	6/72--11/72	Cortright Trailer Ct.
	--	0400036	2/73--12/73	Antelope Creek
	--	0400037	3/73--10/73	Willow Glenn

LEAD PLATE (SULFATION) STATIONS

County	Municipality	Site No.	Dates of Operation	Site Location
Deer Lodge	Anaconda	0020002	2/71 - 2/72	Church of Christ
	"	0020003	2/71 - 2/72	Smelter Main Gate
	"	0020005	4/71 - 12/71	Anaconda Jr. High
	"	0020007	3/73 - 12/73	Post Office
	--	0400003	2/71 - 2/72	Jones Lane
	--	0400003	2/73 - 5/73	Kucera Residence
	--	0400004	2/71 - 12/73	Highway 48 Jct.
	--	0400005	2/71 - 2/72	Lost Creek
	--	0400006	2/71 - 2/72	Lost Creek Highway
	--	0400007	2/71 - 2/72	Racetrack Exit
	--	0400008	2/71 - 2/72	Galen Dugout Bar
	--	0400009	2/71 - 9/73	Warm Springs
	--	0400010	2/71 - 12/73	Johnson Ranch
	--	0400011	2/71 - 12/73	Anaconda Airport
	--	0400012	2/71 - 10/73	Mill Creek Tri RR Crossing
	--	0400013	2/71 - 2/72	Mill Creek Road
	--	0400014	2/71 - 2/72	Mill Creek Picnic Ground
	--	0400015	2/71 - 2/72	Mt. Haggen Livestock
	--	0400016	2/71 - 11/73	Golf Course Exit
	--	0400017	2/71 - 2/72	Little Green High School
	--	0400018	2/71 - 2/72	Crackerville Groc.
	--	0400019	3/71 - 1/72	Galen Viaduct
	--	0400020	2/72	Bailey Res. I
	--	0400021	10/71 - 12/73	Johnson Residence
	--	0400022	11/71 - 2/72	Bailey Res. II
	--	0400023	10/71 - 2/72	Mathews Residence

County	Municipality	Site No.	Dates of Operation	Site Location
	--	0400024	10/71 - 2/72	Montana Power Sub.
	--	0400025	10/71 - 12/73	Opportunity Main St.
	--	0400026	1/73 - 12/73	Poor Farm
	--	0400028	11/71 - 9/73	Durant Canyon
	--	0400036	3/73 - 12/73	Willow Glen
	--	0400037	3/73 - 10/73	Antelope Creek
	--	0400038	3/73 - 10/73	Tailings Hill
Silver Bow	Butte	0160001	8/71 - 3/72	Harrison Street Fire Station
	"	0160002	2/71 - 3/72	Webster-Garfield School
	"	0160003	8/71 - 3/72	Silver Bow General Hospital
	"	0160004	2/71 - 7/71	Shittier School
	"	0160005	3/71 - 3/72	Greeley School
	"	0160006	2/71 - 2/72	Courthouse
	"	0160007	4/71 - 7/71	Old Emerson School
	--	1480006	11/71	S. of Stauffer Pond
	--	1480007	2/71 - 3/72	Ramsay School
Powell	Deer Lodge	0380001	7/71 - 2/72	Powell County courthouse
	"	0380002	2/71 - 5/71	City Hall
	--	1260005	3/69 - 2/72	Lahman Residence

SODIUM FORMATE PLATE (F^-) STATIONS

County	Municipality	Site No.	Dates of Operation	Site Location
Deer Lodge	Anaconda	0020005	4/71 - 2/72	Anaconda Junior High
	--	0400002	7/71	Jones Lane
	--	0400021	10/71 - 2/72	Johnson Residence
	--	0400022	10/71 - 3/72	Bailey Residence
	--	0400023	10/71 - 5/72	Mathews Residence
	--	0400025	10/71 - 3/72	Opportunity Main Street
	--	0400028	11/71 - 9/73	Durant Canyon
Silver Bow	Butte	0160001	7/71 - 3/72	Harrison Street Fire Station
	"	0160002	3/71 - 3/72	Webster Garfield School
	"	0160003	7/71 - 3/72	Silver Bow General Hospital
	"	0160004	2/71 - 6/71	Whittier School
	"	0160005	4/71 - 3/72	Greeley School
	"	0160006	4/71 - 3/72	Courthouse
	"	0160007	5/71 - 6/71	Old Emerson School
	--	1480001	2/71 - 11/73	Ramsay West
	--	1480002	2/71 - 11/73	Ramsay North
	--	1480003	2/71 - 11/73	Silver Bow Exit
	--	1480004	3/71 - 11/73	ESE of Stauffer Chemical
	--	1480005	5/71 - 11/73	S of Stauffer Chemical
	--	1480006	3/71 - 11/73	S of Stauffer Pond
	--	1480007	2/71 - 2/72	Ramsay School
	--	1480008	10/71	Ramsay River West
Powell	Deer Lodge	0380001	6/71 - 3/72	Powell County Courthouse
	"	0380002	2/71 - 5/71	City Hall

County	Municipality	Site No.	Dates of Operation	Site Location
Powell	--	1260001	11/73	Beck Residence
	--	1260007	10/73 - 11/73	N. Across Highway
	--	12600013	10/73 - 11/73	Rocky Mountain Phospate B
	--	12600017	¢/73 - 11/73	NW on Hill

Calcium Formate Paper (F^-) Stations

County	Municipality	Site No.	Dates of Operation	Site Location
Deer Lodge	Anaconda	0020005	2/71--3/72	Anaconda Jr. High
	--	0400022	10/71--11/71	Bailey Res.
Silver Bow	Butte	0160001	7/71--3/72	Harrison St. Fire Sta.
	"	0160002	2/71--3/72	Webster-Garfield School
	"	0160003	7/71--3/72	Silver Bow Gen Hosp.
	"	0160004	2/71--7/71	Whittier School
	"	0160005	2/71--3/72	Greeley School
	"	0160007	2/71--7/71	Old Emerson School
	--	1480001	7/71--11/73	Ramsay West
	--	1480002	3/71--11/73	Ramsay North
	--	1480003	2/71--2/72	Silver Bow Exit
	--	1480004	3/71--11/73	ESE of Stauffer Chem.
	--	1480005	3/71--11/73	S of Stauffer Chem.
	--	1480006	3/71--11/73	S of Stauffer Pond
	--	1480007	3/71--3/72	Ramsay School
	--	1480008	4/71--2/72	Ramsay River West
Powell	--	1260001	1/69--11/73	Beck Res.
	--	1260002	1/69--2/72	North Station
	--	1260003	1/69--11/73	Mullenberg
	--	1260004	3/69--11/73	Rocky Mtn. Phos. A
	--	1260005	1/69--10/73	Lahman Res.
	--	1260006	1/69--11/73	E. Garrison
	--	1260007	1/69--11/73	N. Across Highway
	--	1260008	1/69--11/73	W. In Garrison
	--	1260009	1/69--3/72	W. Meadow
	--	1260010	1/69--3/72	W. Garrison
	--	1260012	1/69--3/72	S. Garrison

Calcium Formate Paper (F^-) Stations
(continued)

County	Municipality	Site No.	Date of Operation	Site Location
Powell	--	1260013	3/69--11/73	Rocky Mtn. Phos. B
	--	1260015	3/69--11/73	Rocky Mtn. Phos. C
	--	1260016	8/70--9/73	Rocky Mtn. Phos. D

Vegetation (F^-) Sampling Stations

County	Municipality	Site No.	Dates of Operation	Site Location
Silver Bow	--	1480001	2/72	Ramsay West
	--	1480004	1/72	ESE of Stauffer Chem
	--	1480005	1/72	S of Stauffer Chem
	--	1480006	1/72	S of Stauffer Pond
	--	1480002	3/71--11/71	Ramsay North
	--	1480003	2/71--10/71	Silver Bow Exit
	--	1480008	4/71--11/71	Ramsay River West
Powell	--	1260003	6/69--2/72	Mullenberg
	--	1260005	7/72	Lahman Res.
	--	1260007	3/69--2/72	N Across Hwy.
	--	1260010	3/69--2/72	W. Garrison
	--	1260002	3/69--10/71	N. Station
	--	1260006	3/69--10/71	E. Garrison
	--	1260009	3/69--10/71	W. Meadow
	--	1260011	3/69--10/71	Jens
	--	1260012	3/69--10/71	S. Garrison
	--	1260014	3/69--10/71	Pistol Range

Wind Stations (MAQB)

County	Municipality	Site No.	Dates of Operation	Site Location
Deer Lodge	--	0400003	12/72--5/73	Kucera Res.
	--	0400025	6/72--11/72	Opportunity Main St.
	--	0400026	12/71--12/72	Poor Farm
	--	0400027	11/71--3/72	Warm Springs
	--	0400035	8/72	Cortright Trailer Ct.
	--	0400037	2/73--8/73	Antelope Creek
Silver Bow	Butte	0160001	12/71--3/72	Harrison St. Fire Sta.
Powell	Deer Lodge	0380001	1/72--6/72	Powell Co. Courthouse

16-2.14(1)-S14040 AMBIENT AIR QUALITY STANDARDS

(1) In accordance with section 69-3909, subsection 12 of the Clean Air Act of Montana, on May 27, 1967, the board adopted the Ambient Air Quality Standards shown below.

(2) Until additional pertinent information becomes available with respect to the effects of the substances listed below, the following air quality criteria shall apply in Montana.

Pollutants	Standards (Maximum permissible concentrations)
Sulfur dioxide[a]	0.02 ppm, maximum annual average 0.10 ppm, 24-hour average, not to be exceeded over 1 percent of the days in any 3-month period. 0.25 ppm not to be exceeded for more than one hour in any 4 consecutive days
Reactive sulfur (sulfation[b])	0.25 milligrams sulfur trioxide per 100 square centimeters per day, maximum annual average 0.50 milligram sulfur trioxide per 100 square centimeters per day, maximum for any one-month period
Suspended sulfate[c]	4 micrograms per cubic meter of air, maximum allowable annual average 12 micrograms per cubic meter of air, not to be exceeded over 1 percent of the time
Sulfuric acid mist[d]	4 micrograms per cubic meter of air, maximum allowable annual average 12 micrograms per cubic meter of air, not to be exceeded over 1 percent of the time 30 micrograms per cubic meter of air, hourly average, not to be exceeded over 1 percent of the time
Hydrogen sulfide[e]	0.03 ppm, ½-hour average, not to be exceeded more than twice in any 5 consecutive days

16-2.14(1)-S14030 WOOD WASTE BURNERS

(6) No person shall use a wood waste burner forthe burning of other than production process wood waste transported to the burner by continuous flow conveying methods.

(7) New wood waste burner definition:

(a) Any wood waste burner constructed or installed after the effective date of this regulation.

(b) Any wood waste burner replaced or altered after the effective date of this regulation as to have any effect on the production or control of air contaminants.

(c) Any wood waste burner moved after the effective date of this regulation to another premise involving a change of address.

(d) Any wood waste burner purchased or otherwise acquired and to be operated after the effective date of this regulation by a new owner or when a new lessee desires to operate such burner.

(8) Exception:

For building of fires in wood waste burners, the darkness or opacity provision and the particulate provisions under section (2) of this regulation may be exceeded for not more than 60 minutes in 8 hours.

Pollutants	Standards (Maximum permissible concentrations)
	0.05 ppm, ½-hour average not to be exceeded over twice a year
Total Suspended particulate[f]	75 micrograms per cubic meter of air, annual geometric mean 200 micrograms per cubic meter of air, not to be exceeded more than 1 percent of days a year
Settled particulate (Dustfall[g])	15 tons per square miles per month, 3-month average in residential areas 30 tons per square mile per month, 3-month average in heavy, industrial areas
Lead[h]	5.0 micrograms per cubic meter of air, 30-day average
Beryllium[i]	0.01 micrograms per cubic meter of air, 30-day average
Fluorides, total (as HF) in air[j]	1 part per billion parts of air, 24-hour average
Fluorides (asF) in forage[k] for animal consumption - dry weight basis	35 parts per million
Fluorides (gaseous)[l]	0.3 micrograms per square centimeter per 28 days

[a] Sulfur dioxide measured by West-Gaeke or conductometric method.

[b] Sulfation measured by lead-peroxide candle

[c] Suspended sulfate measured by high volume sampler - turbidmetric procedure

[d] Sulfuric acid mist- Air Pollution Control District, County of Los Angeles, APCD - Sulfuric acid 13-49

[e] Hydrogen sulfide measured by methylene blue method - lead acetate tape for screening and monitoring

[f] Suspended particulate measured by high-volume sampler

[g] Dustfall measured by container open to atmosphere

[h] Suspended lead measured by high-volume sampler - dithizone and/or spectrophotometric procedures

[i] Suspended beryllium measured by high-volume sampler - fluorometric and/or spectrophotometric method.

[j] Total fluoride measured by impingers - Winter-Willard distillation procedure (SPADNS color)

[k] Forage cut, dried, ashed and subjected to Winter-Willard distillation procedure (SPADNS color)

[l] Gaseous fluorides measured by calcium formate paper technique in board standard shelter - Winter-Willard distillation procedure (SPADNS color)

The ambient air quality standards listed describe a level of air quality designed to protect people from the adverse effects of air pollution; and they are intended further to promote maximum comfort and enjoyment in use of property consistent with economic and social well being of the community.

Ambient air quality standards are used as a tool in achieving cleaner air, not as a license to permit unnecessary degradation of air quality which would thwart attainment of the long-range goal to maintain a reasonable degree of air purity.

These standards are not intended to represent the ultimate in air quality achievement. It is anticipated that research and development will gradually make possible cleaner air at lower cost. As evidence accumulates on deleterious effect of the contaminant, present objectives will be revised or additional standards established. The standards are designed to protect the health, welfare and comfort of the public and to minimize economic losses.

Because some pollutants combine chemically to form more harmful materials than the original emissions, ascribing a single effect to a single pollutant would be an erroneous over-simplification. The standards, therefore, apply to air containing a variety of pollutants. Although reaching the goals will result in benefits, no allowance for the time needed to achieve them was considered in their selection. They are intended to apply to areas where people live or where an adverse effect may occur.

The board, in adopting these standards, intends them to be goals and guidelines and so interprets the legislative intent of the word "standards" in section 69-3909 of the Clean Air Act of Montana.

(3) The sampling and analytical procedures employed to measure ambient levels of contaminants are to be consistent with obtaining accurate results which are representative of the conditions being evaluated. The sampling and analytical techniques enumerated may be used directly or employed as reference standards against which other methods may be calibrated.

NATIONAL AMBIENT AIR QUALITY STANDARDS

POLLUTANT	PRIMARY STANDARD	SECONDARY STANDARD	CONVERSION ppm to ug/M3	FACTORS ug/M^3 to ppm
1. Sulfur Oxides	80 ug/M^3 (0.03 ppm) annual arith. mean 365 ug/M^3 (0.14 ppm) max. 24 hr. conc. not to be exceeded more than once a year.	1300 ug/M^3 (0.6 ppm) max. 3 hr. conc. not to be exceeded more than once a year.	2860	0.35 x 10^{-3}
2. Particulate Matter	75 ug/M^3 annual geom. mean 260 ug/M^3 max. 24 hr. conc. not to be exceeded more than once a year.	60 ug/M^3 annual geom. mean 150 ug/M^3 max. 24 hr. conc. not to be exceeded more than once a yr.	----	----
3. Carbon Monoxide	10,000 ug/M^3 (9 ppm) max. 8 hr. conc. not to be exceeded more than once a year. 40,000 ug/M^3 (35 ppm) max. 1 hr. conc. not to be exceeded more than once a year.	Same as primary. Same as primary	1150	0.87 x 10^{-3}
4. Photo Chemical Oxidants (corrected for NO_2 and SO_2 interference)	160 ug/M^3 (0.08 ppm) max. 1 hr. conc. not to be exceeded more than once a year.	Same as primary.	1960	0.51 x 10^{-3}
5. Hydrocarbons (corrected for CH_4)	160 ug/M^3 (0.24 ppm) max. 3 hr. conc. (6 to 9 a.m.) not to be exceeded more than once a year.	Same as primary.	655	1.53 x 10^{-3}
6. Nitrogen Oxides (as Nitrogen Dioxide)	100 ug/M^3 (0.05 ppm) annual arith. mean.	Same as primary	1852	0.540 x 10^{-3}

REFERENCES

1. National Oceanic and Atmospheric Administration, Environmental Data Service, Asheville, NC, Climatological Data - Montana Jan 1971-Dec 1973, Vol. 74-76.

2. Environmental Impact Statement for the Air Pollution Variance Requested by: The Anaconda Company for its smelter at Anaconda, Montana, Department of Health and Environmental Sciences, State of Montana, April 26, 1974.

3. Letter from Mr. Frank J. Laird, Jr., to David Maughan, February 1, 1974.

4. Air Quality Bureau calculations.

5. Air Quality Bureau calculations.

6. Letter from R. J. Harry, Stauffer Chemical Company, Butte, Montana to Jim Gelhaus, State Department of Health and Environmental Sciences, dated March 15, 1974.

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